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Original Article

Survey of iodine nutritional status in 2011, Zhejiang, China

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Background: Universal salt iodization (USI) was introduced in China in 1995, but whether the iodine status is optimal is questionable. This study was conducted to assess the iodine nutrition among Zhejiang population in coastal regions in China. **Methods:** A cross-sectional survey for iodine nutritional status was conducted with general population (n=10,350), including pregnant and lactating women (n=450 each) selected by stratified multi-stage sampling. Iodine content in drinking water, table salt and urine, were determined using arsenic-cerium catalytic spectrophotometry, the direct titration and the arsenic-cerium catalytic spectrophotometry, respectively, and daily iodine intake was estimated by 3 days of 24-hour recall method. **Results:** The median iodine content in drinking water was 2.46 μg/L, Zhejiang belonged to the region of iodine deficiency in outer environment according to China standard. The median iodine content in table salt was 27.9 mg/kg, conforming to the standard requirements; the household coverage rate of qualified iodized salt reached 76.8%, which does not reach the standard requirement of WHO >90%. The dietary iodine intake of a reference individual averaged 379 μg/d, which indicated that the current iodine intake in diet was appropriate. In addition, the median urinary iodine concentration (UIC) was 162 μg/L in general population, and 130 μg/L in pregnant women, which didn't reach the standard requirements. **Conclusion:** The current dietary iodine intake in Zhejiang was generally sufficient and safe, but there is a risk of iodine deficiency among pregnant women and the population who do not consume iodized salt.

Key Words: iodine deficiency disorder (IDD), universal salt iodization (USI), urinary iodine concentration (UIC), dietary iodine intake, iodine excess

INTRODUCTION

Although iodine is an essential trace element for synthesis of thyroid hormones, either insufficient or excessive iodine intake may lead to thyroid disease. As the most effective and economic measure to prevent IDD,[1] the USI program has been implemented in China since 1995 and proved to be an effective strategy: according to the evaluation of World Health Organization (WHO), IDD had been eliminated in China by 2003.[2] With the rapid economic development of China in the past two decades, changes in diet and health awareness might affect iodine intake to an unclear extent, especially in developed coastal regions of China. It was argued that iodine intake might be excessive in regions where iodine abundant food was easily available. Therefore, the USI program was questioned for whether it should continue or be adjusted according to iodine nutritional status of local population. Actually, relevant data showed that household coverage of qualified iodized salt was down in recent years, because more and more consumers were seeking non-iodized salt instead of iodized salt due to their unproved assumptions. It is important to make this issue clear, since such practices might undermine the effort over the past two decades of controlling IDD.

Located on the southeast coast of China with a coastline as long as 2,250 kilometers, Zhejiang province is one of the most developed regions in China and its coastal region is abundant in marine products. To assess iodine nutritional status, an important index is the assessment of the dietary iodine intake.[3] Since more than 80% of human iodine intake is excreted via urine,[4] determination of UIC is currently the most practical method to assess iodine nutritional status of the population in certain regions.[5,6] This survey aimed to systematically assess the iodine nutritional status of the population in Zhejiang province after 16 years of salt iodization from three aspects, including household coverage of qualified iodized salt, dietary iodine intake and UIC, providing basic information for government decision-making.

SUBJECTS AND METHODS

Subjects

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A cross-sectional survey was conducted on the population in Zhejiang province from April to June in 2011 and the subjects were permanent residents and others who had lived there for more than 3 years. After a preliminary investigation, subjects were excluded when exposed to the followings 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 the population of Zhejiang province. As shown in Figure 1, firstly, the Proportionate to Population Size (PPS) sampling was applied to select 30 counties (districts) from 11 cities of Zhejiang province; secondly, one town (street) were randomly selected in each county (district); thirdly, one village (community) was randomly selected from each town (street); fourthly, 100 households were randomly selected in each village as participants for questionnaire survey and determination of the iodine content in drinking water, table salt, and urine. Fifty households were randomly selected from above 100 households for the dietary survey. Fifteen pregnant women and fifteen lactating women were randomly recruited from records registered from September 1 to September 30, 2011, in the above selected towns (streets) from each county (district), respectively.

In the preliminary investigation, large differences in eating habits were found between coastal and inland areas. Coastal areas were defined as those selected cities with a long coastline including Ningbo, Taizhou, Wenzhou, Jiaxing as well as the island Zhoushan city, and the remaining regions were defined as inland areas. See Figure 2 for the geographical distribution of survey counties (districts) in Zhejiang province. The survey protocol was authorized by Ethics Committee of Zhejiang Provincial Center for Disease Control and Prevention. All respondents provided their informed consent.

Methods

The face-to-face questionnaire survey was conducted by trained and qualified investigators using a unified questionnaire. The questionnaire included questions related to gender, age, and nationality, personal or family history of thyroid diseases. The surveyed households underwent determination of the iodine content in drinking water and table salt, and all subjects underwent determination of UIC. The 3 days of 24-hour dietary recall method was used to estimate daily dietary iodine intake of a reference man.[7,8]

Drinking water collection and iodine determination

A sample of drinking water was collected from taps or tanks in every household (not less than 100 mL), sealed and kept out of the sun at room temperature. The iodine content was determined using arsenic-cerium catalytic spectrophotometry.[9]

Table salt collection and iodine determination

A sample of table salt, collected from every household (not less than 50 g), was sealed and kept in dark place at room temperature. The iodine content was measured using direct titration.[10,11]

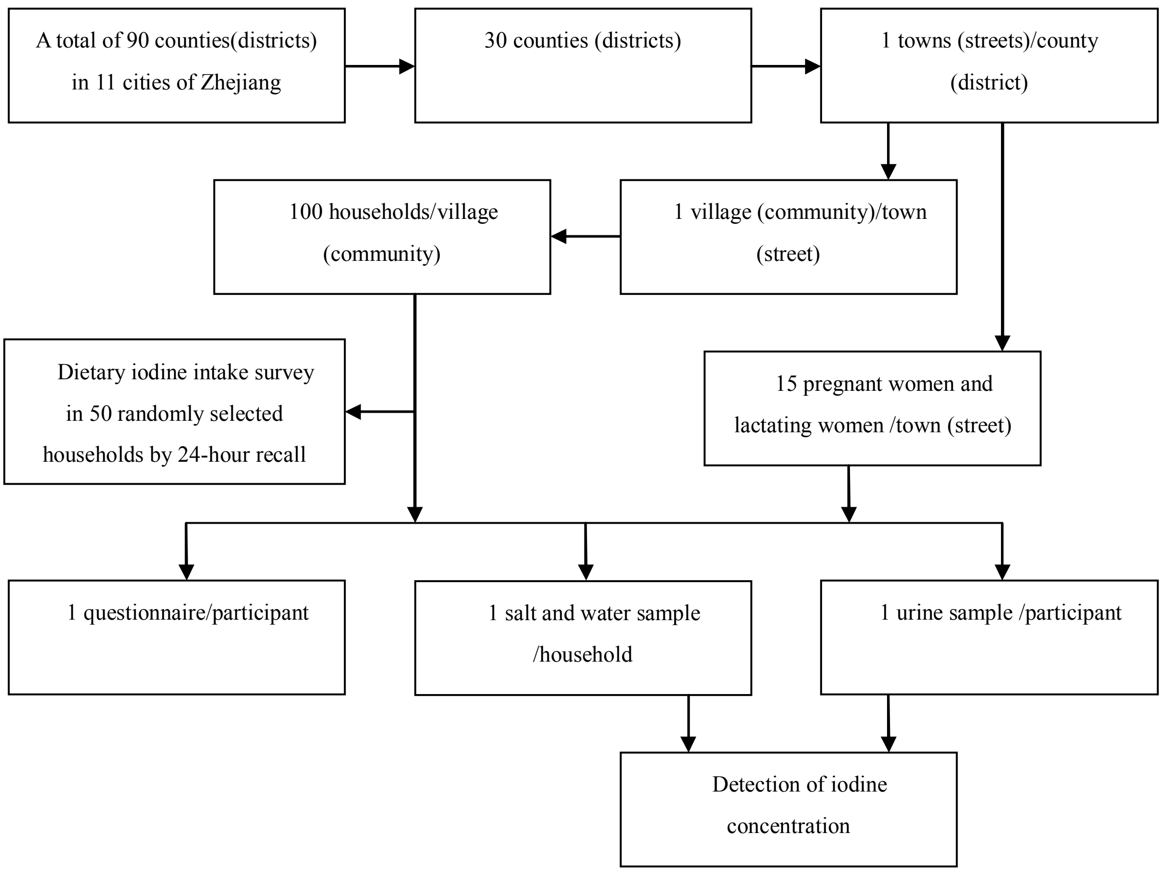

Figure 1. Summary of survey sampling procedures

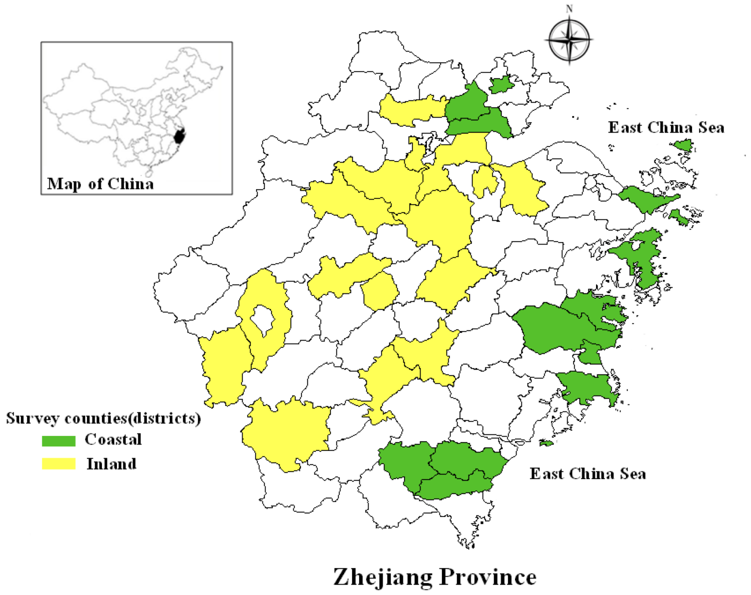

Figure 2. Geographical distribution of the survey counties (districts) in Zhejiang province of China.

Table 1. Distribution of UIC in survey subjects of Zhejiang province, China (2011)

Groups	Median UIC (μg/L)	Iodine status
General population	<20	Severe iodine deficiency
	20-49	Moderate iodine deficiency
	50-99	Moderate iodine deficiency
	100-199	Adequate iodine nutrition
	200-299	Above requirements (Might pose a slight risk of adverse health consequences)
	≥300	Excessive
Pregnant women	<150	Insufficient
	150-249	Adequate
	250-499	Above requirements
	≥500	Excessive
Lactating women	<100	Insufficient

Urine sample collection and iodine determination

Morning fasting urine samples of all participants (not less than 20 mL) were collected, sealed and kept at -20 °C, followed by determination of urinary iodine via arsenic-cerium catalytic spectrophotometry.[11,12]

Dietary assessment

Fifty households were randomly selected from 100 households in each site. Individual food intake surveys were conducted on all family members in surveyed households, for consecutive three days (including two working days and one rest day) by investigators who used food models and the 24-hour recall method. The information of children and elderly people without clear memories was provided by their caregivers. The individual daily food intake was obtained and the 3 days of household condiment consumption data was collected by weighing method; the drinking water intake was calculated according to daily intake of 1.2 L for a normal adult.[13] The iodine content in foods was obtained by referring to the "China Food Composition Table",[14] and the iodine content in drinking water and table salt was obtained from the test 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 with 18 years old, weighted at 60 kg, and engaged in light physical activity.[15] The estimated average requirement (EAR) is 120 μg/d as recommended by Chinese Nutrition Society, the recommended nutrient intake (RNI) is 150 μg/d; and the daily tolerable upper intake level (UL) is 1,000 μg/d.[13] Criteria for population iodine nutrition evaluation was subject to the standard published by WHO/UNICF/ICCIDD[11] (see Table 1).

Statistical analysis

SAS 9.13 software package was used for statistical analysis. The dietary iodine intake was expressed as the mean (SD), whereas water iodine, salt iodine and urinary iodine values were expressed as the median (25th-75th percentiles). The sample population was compared with the age distribution of total population in Zhejiang for goodness of fit test; Wilcoxon test was used to compare concentrations of water iodine, salt iodine and urinary iodine, and one-way ANOVA was adopted to compare the dietary iodine intake; Cochran-Mantel-Haenszel test was applied to compare gender proportion household coverage of qualified iodized salt and the contribution rate of dietary. All tests were two-sided, and $p<0.05$ was considered to be statistically significant.

RESULTS

Comparison between the sample and the total population in Zhejiang

As shown in Table 2, goodness of fit test was carried out in order to make a comparison between age distribution of the surveyed sample and total population in Zhejiang province in 2010. The result showed there was no statistical differences.

By comparing sex ratio of survey sample to total population of Zhejiang, it was found that the sex ratio in present sample was 106.8:100 (male: 5,345, female: 5,005), which is similar to the sex ratio of total population of Zhejiang within the corresponding age range ($p=0.137$).

Summary of sample collection

The numbers and proportions of potentially collected samples (potential samples), actually collected samples (responses samples) and satisfactory samples available for analysis were shown in Table 3.

Iodine determination in drinking water, table salt and urine

The median iodine concentration in drinking water was 2.46 μg/L (25th-75th percentiles: 1.10-6.72 μg/L) in total, while the iodine concentrations were 2.60 μg/L (25th-75th percentiles: 1.12-6.88 μg/L) and 2.36 μg/L (25th-75th percentiles: 0.89-5.89 μg/L), respectively in coastal and inland areas, which showed no statistical difference.

The median iodine content in table salt was 27.9 mg/kg (25th-75th percentiles: 22.9-33.4 mg/kg) and the general population household coverage rate of qualified iodized salt was 76.8% (6,441/8,382) in total. Both the median iodine content in iodized salt and household coverage rate of qualified iodized salt in the coastal areas were lower than those in the inland areas where the median iodine content in iodized salt was 26.1 mg/kg vs. 31.5 mg/kg; household coverage rate of qualified iodized salt was 64.7% vs 86.8% (all p values<0.05).

Median UIC in general population was 162 μg/L (25th-75th percentiles: 104-246 μg/L), with UIC <100 μg/L (the cutoff for iodine insufficiency) and UIC ≥300 μg/L (the cutoff for iodine excess), respectively, accounting for 22.9% (1,920/8,382) and 14.5% (1,212/8,382). The proportions of UIC between 100 to 199 μg/L (adequate iodine nutrition) and 200 to 299 μg/L (above requirements) were 39.9% (3,343/8,382) and 22.8% (1,907/8,382), respectively (see Figure 3). Coastal areas had lower median UIC than inland areas (151 μg/L vs 175 μg/L; $p<0.05$) and median UIC of pregnant women was 130 μg/L (25th-75th percentiles: 89.7-181 μg/L), and 61.6% (265/430) had UIC <150 μg/L (the cutoff for iodine insufficiency), while 1.6% (7/430) had UIC ≥500

Table 2. Goodness of fit test of age distribution of the current sample and the population in Zhejiang in 2010

Age	Current sample (%) Si			Population in Zhejiang (%) Pi			$(Si-Pi)^2/Pi$		
group (years)	Male	Female	Total	Male	Female	Total	Male	Female	Total
0～	5.31	5.35	5.33	5.23	5.18	5.21	0	0.01	0
5～	6.40	6.36	6.38	5.15	5.17	5.16	0.31	0.28	0.29
10～	5.08	5.00	5.04	5.15	5.13	5.14	0	0	0
15～	5.81	5.72	5.77	6.08	6.07	6.08	0.01	0.02	0.02
20～	5.87	5.83	5.85	7.66	7.60	7.62	0.42	0.41	0.41
25～	7.38	7.41	7.39	7.64	7.75	7.69	0.01	0.01	0.01
30～	5.86	5.95	5.92	6.85	6.78	6.81	0.14	0.10	0.12
35～	6.64	6.68	6.66	6.94	6.92	6.93	0.01	0.01	0.01
40～	6.73	6.75	6.74	7.30	7.35	7.33	0.04	0.05	0.05
45～	6.83	6.98	6.89	7.66	7.69	7.68	0.09	0.07	0.08
50～	9.79	9.75	9.77	9.67	9.70	9.68	0	0	0
55～	10.00	9.98	10.00	9.02	9.08	9.05	0.11	0.09	0.10
60～	9.90	9.85	9.87	9.33	9.35	9.34	0.03	0.03	0.03
65～	8.38	8.39	8.39	6.32	6.23	6.28	0.67	0.75	0.71
Chi-square value							1.84	1.83	1.83

The data were analysed by Goodness of fit test. Degree of freedom: (k-1)-2=11, χ^2_α=0.05(10)=19.7, all χ^2 values were less than their cut-off points.

Table 3. Summary of sample collection

Population	Sample	Number of potential samples	Number of responses/ samples obtained (%)	Number of satisfactory samples/investigations (%)
	Table salt	3900	3838/98.4	3631/94.6
	Drinking water	3900	3826/98.1	3700/96.7
	Questionnaire	11250	10417/92.6	9844/87.5
General participants	Urine	10350	9460/91.4	8382/88.6
	Dietary survey	5160	4943/95.8	4696/95.0
Pregnant women	Urine	450	442/98.2	430/97.3
Lactating women	Urine	450	446/99.1	439/98.4

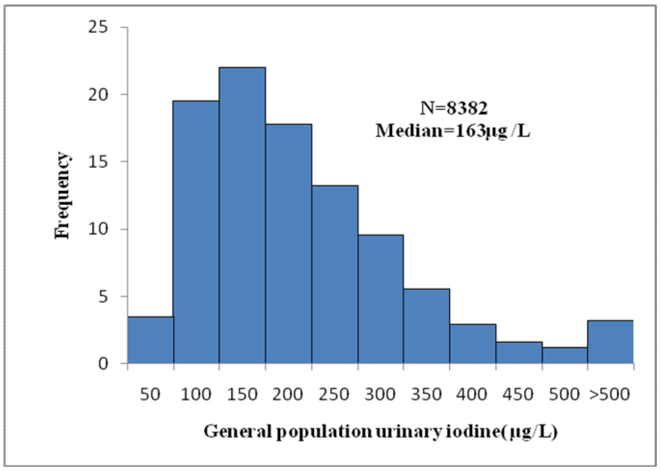

Figure 3. Frequency distribution of UIC in general population

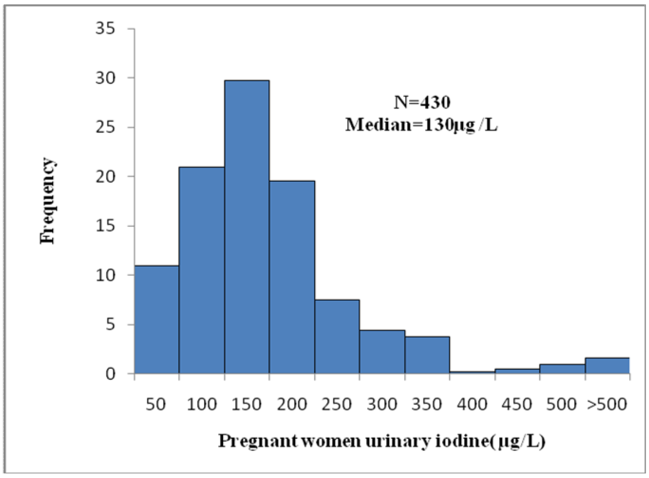

Figure 4. Frequency distribution of UIC in pregnant women

μg/L (the cutoff for iodine excess) (see Figure 4). Pregnant women in coastal areas had lower median UIC than those in inland areas (109 μg/L vs 142 μg/L; $p<0.05$). The median UIC of lactating women was 161 μg/L (25th-75th percentiles: 93.9-254 μg/L), and the proportion of UIC <100 μg/L (the cutoff for iodine insufficiency) was 13.0% (57/439) (see Figure 5). The median UIC of lactating women in coastal areas was lower than that of inland areas (148 μg/L vs 170 μg/L; $p<0.05$). Median UICs of the population from households not using qualified iodized salt was less than 100 μg/L, which was lower than corresponding populations with households using qualified iodized salt. See Table 4 for the UIC distribution of the participants.

Dietary iodine assessment

The average daily dietary iodine intake of a reference man from residents in Zhejiang province was 379 μg/d (SD=107 μg/d), and the iodine intake of participants in inland areas was higher than the coastal areas (443 μg/d vs 314 μg/d; $p<0.001$); the iodine intake of participants from edible qualified iodized salt was higher than that from inedible qualified iodized salt (477 μg/d vs 107 μg/d; $p<0.001$). As shown in Table 5, without considering the loss of cooking, the average contribution rate of dietary iodine intake of table salt was 74.1%; the average contribution rate of drinking water was 1.2%; and the average contribution rates of laver seaweed, fish, and kelp were 16.1%, 1.2%, and 1.2%, respectively. Coastal areas showed a lower contribution rate of table salt than the inland areas (63.2% vs 81.9%, $p<0.001$), and the contribution rates of drinking water, laver seaweed, fish, and kelp in coastal areas were higher than the inland areas (drinking water 1.6% vs 1.0%; laver seaweed 22.6% vs 11.3%; fish 1.8% vs 0.7%; kelp 2.5% vs 0.3%; $p<0.001$).

As shown in Table 6, The proportion of low dietary iodine intake (<120 μg/d) in coastal areas was higher than inland areas (29.9% vs 12.8%, $p<0.001$), whereas the inland areas had a higher proportion of subjects with adequate dietary iodine intakes (150 μg/d to 1000 μg/d) than the coastal areas ($p<0.05$).

Households with non-coverage of qualified iodized salt had a much higher proportion with low dietary iodine intakes than households using qualified iodized salt (68.4% vs 7.4%, $p<0.001$), whereas the proportion of adequate dietary intake of household non-coverage of qualified iodized salt were lower than that of household coverage of qualified iodized salt ($p<0.001$).

DISCUSSION

According to the present survey, the median iodine content of household drinking water was less than 10 μg/L

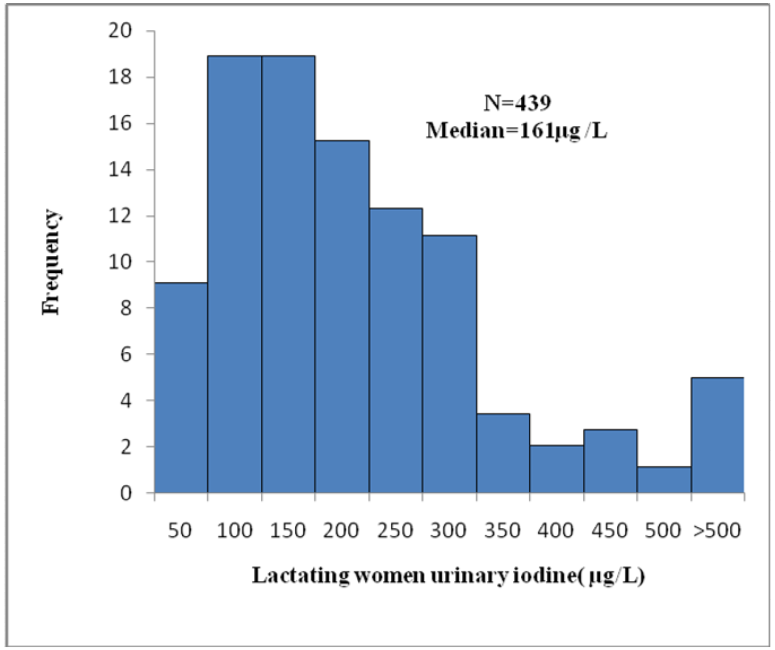

Figure 5. Frequency distribution of UIC in lactating women.

Table 4. Distribution of UIC in survey subjects of Zhejiang province, China (2011)

Group	Coastal areas		Inland areas		Household coverage of qualified iodized salt†		Household non-coverage of qualified iodized salt		Total	
	N	Median (25th,75th percentiles), μg/L	N	Median (25th,75th percentiles), μg/L	N	Median (25th,75th percentiles), μg/L	N	Median (25th, 75th percentiles), μg/L	N	Median (25th, 75th percentiles) , μg/L
General population	4196	151 (100, 235)	4186	174 (109, 257)*	6441	191 (138, 269)	1941	96.0 (70.0, 117)**	8382	162 (104, 246)
Pregnant woman	218	109 (77.2, 166)	212	142 (109, 190)*	323	148 (111, 190)	107	72.0 (36.5 ,91.9)**	430	130 (89.7, 181)
Lactating women	221	148 (90.0, 245)	218	170 (97.1, 267)*	342	188 (119, 278)	97	84.0 (43.4, 130)**	439	161(93.9, 254)

†The household coverage of qualified iodized salt was considered as all family members were eating qualified iodized salt, so did household non-coverage of qualified iodized salt.
* The UIC was compared between coastal and inland areas, $p<0.05$ (Wilcoxon test).
**The UIC was compared between household coverage of qualified iodized salt and household non-coverage of qualified iodized salt, $p<0.001$ (Wilcoxon test).

Table 5. Daily iodine intake and the contribution rate of dietary iodine.

Food sorting	Coastal areas		Inland areas		Total	
	Average iodine intake (SD) (μg/d)	Contribution rate of iodine intake (%)	Average iodine intake (SD) (μg/d)	Contribution rate of iodine intake (%)	Average iodine intake (SD) (μg/d)	Contribution rate of iodine intake (%)
Drinking water	5.0 (1.1)	1.6	4.4 (1.2)	1.0**	4.7 (1.1)	1.2
Table salt	199 (47.6)	63.2	363 (96.4)	81.9**	280 (95.8)	74.1
Laver seaweed	71.6 (16.2)	22.6	50.2 (14.1)	11.3**	60.9 (15.2)	16.1
Fish	5.8 (1.5)	1.8	3.2 (1.1)	0.7**	4.5 (1.3)	1.2
Kelp	7.9 (1.8)	2.5	1.3 (0.3)	0.3**	4.6 (1.1)	1.2
Other food	25.4 (6.3)	8.1	21.3 (6.1)	4.8**	23.4 (6.2)	6.2
Total	314 (86.9)	100	443 (127)*	100	379 (107)	100

*The average dietary iodine intake was compared between coastal and inland areas, p<0.001 (One-way ANOVA).
**The contribution rate of dietary iodine was compared between coastal and inland areas, p<0.001 (Cochran-Mantel-Haenszel test).

Table 6. Distribution of dietary iodine intake with different intake references

Group (μg/d)	Coastal areas		Inland areas		Household coverage of qualified iodized salt		Household non-coverage of qualified iodized salt		Urine samples†		Total	
	N	%	N	%	N	%	N	%	N	Median (25th,75th percentiles), μg/L	N	%
<120	704	29.9	300	12.8*	267	7.4	737	68.4**	981	75.0 (58.2, 90.0)	1004	21.4
120~	101	4.3	91	3.9	130	3.6	62	5.8	187	100 (97.3, 103)***	192	4.1
150~	1440	61.1	1839	78.6*	3008	83.1	271	25.2**	3202	188 (138, 256)***	3279	69.8
≥1000	111	4.7	110	4.7	214	5.9	7	0.6**	216	513 (440, 650)***	221	4.7

†110 cases of urine test results were lost.
*The proportion of dietary iodine less than 120 μg/d was compared between coastal and inland areas, p<0.001; the proportions of dietary iodine from 150 μg/d to 1000 μg/d were compared, p<0.05 (Cochran-Mantel-Haenszel test).
**The proportions of different iodine intake references were compared between household coverage of qualified iodized salt and household non-coverage of qualified iodized salt, p<0.001 (Cochran-Mantel-Haenszel test).
***The UIC of different iodine intake references were compared with the < 120 μg/d group, p<0.001 (Wilcoxon test).

(the cutoff for iodine insufficiency), which indicated that both in the coastal and inland areas, the geographical environment of Zhejiang province was an iodine-deficiency area according to the standard used in China.[16,17] It also showed that since the drinking water does not reach the adequate criteria, residents in this area need to increase their dietary iodine intakes.

By using 24-hour recall method, which is the most common method for dietary survey,[18] the average daily iodine intake of "a reference man" was determined to be 379 μg/d. According to the standard set by the Chinese Dietary Reference intakes,[13] the current Zhejiang dietary iodine intakes were between the RNI and the UL values, which is the same conclusion reached by previous research.[19] In addition, the daily UL is recommended as 600 μg/d by WHO.[20] Therefore, in general, the present total iodine nutritional status in Zhejiang was adequate and safe, and far from excessive iodine intake. The distribution of dietary iodine intakes showed that the proportion of the population with iodine-deficiency was greater than the those with iodine-excess, especially in coastal areas of Zhejiang province.

Our results showed that the median UIC of general population, pregnant and lactating women were 162 μg/L, 130 μg/L, and 161 μg/L, respectively. According to the WHO/UNICEF/ICCIDD[11] iodine nutrition assessment standard, iodine nutrition of general population and lactating women was adequate, but 61.6% of the pregnant women had an inadequate iodine nutrition level, especially in coastal areas. Due to the extra demand of iodine from the fetus, pregnant woman are particularly vulnerable to damage of iodine deficiency.[21] What is more, iodine deficiency during pregnancy would lead to irreversible damage to the development of fetal brain.[22,23,24,25]

Since the iodized salt was introduced, iodine nutritional status has been monitored in the population, however mainly in school-age children, who may be unsuitable subjects to represent the iodine nutritional status of the whole population. Pearce EN et al[4] believed that monitoring pregnant women and other vulnerable groups should be given the same priority as children's iodine nutrition. We found the UIC among pregnant women was 130 μg/L, which is a level consistent with previous surveys of pregnant women in 11 provinces in China,[26] in Zhejiang[27] and Shanghai,[28] China. Moreover, such countries as USA,[29] UK,[30] German,[31] France[32] and New Guinea[33] et al reported similar data on iodine deficiency.

A survey published in 2013 reported that household coverage of iodized salt in the world was about 70%.[4] In this survey, the iodized salt contributed 74.1% of dietary iodine intake, and the contributions of laver seaweed, fish, and kelp were 16.1%, 1.2%, and 1.2%, respectively. The contribution of these seafoods which were considered rich in iodine was markedly lower than the contribution of iodized salt. Therefore, iodized salt is still the main source of dietary iodine intake, although the diet situation has changed in the past two decades.

Current criteria for qualified iodized salt was set as 35(±15) mg/kg, unqualified iodized salt, 5-20 mg/kg or >50 mg/kg, and non-iodized salt, less than 5 mg/kg.[34] According to further research with focus on the general population, the iodine nutrition level of household coverage of qualified iodized salt was adequate, and their iodine intake and median UIC were much higher than that of household non-coverage of qualified iodized salt. Additionally, as the latter's iodine intake and median UIC failed to meet the standard requirements,[11,13] this further demonstrated that iodized salt was the main source of dietary iodine intake. In other words, iodine deficiency would occur, if iodized salt intake was abandoned under the current nutrition conditions in Zhejiang.

Household coverage rate of qualified iodized salt is an important index to assess the coverage of iodized salt consumption.[11] The USI program has been implemented in Zhejiang since 1995, and since then the household coverage of qualified iodized salt had risen from 25.0% in 1995 to 96.3% in 2000, and then dropped to 89.7% in 2004.[35] In this survey, the household coverage of qualified iodized salt was 76.8%, which included 64.7% in coastal areas, and 86.8% in inland areas. Both of these values failed to meet the standard for elimination of IDD (>90%),[11,36] and they were even lower than the national average level.[37] What is more, a national large investigation in 2005[38] revealed that the median of urine iodine among children aged 8-10 years was 246 μg/L, which is above requirements, indicating there is space for the down-regulation of iodized salt concentration. Hence, in March 15, 2012, a fresh standard of iodized salt concentration was implemented in China.[39] The iodine content was reduced from 35(±15) mg/kg to 25(±30%) mg/kg according this revised standard. The down-regulation of iodized salt concentration would definitely increase the risk of iodine deficiency among certain population, especially pregnant women, since qualified iodized salt intake rate declined and iodine nutrition was deficient among pregnant women.

This survey didn't take into consideration the loss of iodine in foods and table salt in the cooking process, which may be as much as 20% according to WHO/UNICEF/ICCIDD[11]. A survey in Shanghai indicated the loss rate was a 24.6% in the Chinese cooking process.[40] Therefore, the daily iodine intake of the population in Zhejiang province was certainly overestimated. Taking the loss of cooking into consideration, the dietary iodine intake was estimated between the RNI and the UL, while in fact the proportion of dietary iodine intake might be lower than the current study findings.

We had systematically evaluated the iodine concentration in external water environment, household table salt, dietary iodine intake, and urine iodine for determination of the iodine nutritional status of the population in Zhejiang province. This analysis was carried out between coastal and inland areas, and populations with and without household coverage of qualified iodized salt. Our results took into account the effects of areas, consumptions of iodized salt and dietary situation on iodine nutritional status, which provided basic data for cohort study of iodine deficiency's health impact on pregnant women and their infant.

Conclusion

In Zhejiang the current iodine nutrition status was generally adequate, but this study indicated there was a risk of iodine deficiency among pregnant women and those not consuming iodized salt. The household coverage rate of qualified iodized salt was relatively lower than expected, indicating that the USI program is facing a serious challenge to maintain adequate iodine status in the population under investigation.

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AUTHOR DISCLOSURES

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Original Article

Survey of iodine nutritional status in 2011, Zhejiang, China

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2011 年中国浙江省碘营养状况调查

背景：中国自 1995 年即开始实施全民食盐加碘为主的碘缺乏病综合防治策略，但目前居民的碘营养水平是否处于最佳水平仍存在疑问。本研究的目的是评估中国沿海地区浙江省居民的碘营养状况。**方法：**采用分层多级抽样方法对 10350 例的普通人群、450 例的孕妇以及 450 例的哺乳期妇女进行横断面碘营养水平调查。分别采用砷铈催化分光光度法、直接滴定法以及砷铈催化分光光度法对饮用水水样、盐样和尿样进行碘含量测定。日常的碘估计摄入量使用 3 天 24 小时回顾法。**结果：**饮用水水碘中位数 2.46 μg/L，根据中国的标准浙江属于外环境碘缺乏地区；盐碘中位数为 27.9 mg/kg，符合标准要求；合格碘盐食用率为 76.8%，未达到 WHO 要求的大于 90%；标准人均日膳食碘的摄入量为 379 μg/d，其摄入量适宜。此外，普通人群尿碘中位数为 162 μg/L，孕妇尿碘中位数为 130 μg/L，其中孕妇碘营养水平未达到标准要求。**结论：**目前，浙江省居民膳食碘摄入量总体是充足和安全的，但孕妇和非食用碘盐人群其碘缺乏的风险容易隐藏在全民食盐加碘的政策之下。

关键词：碘缺乏病（IDD）、全民食盐加碘（USI）、尿碘浓度（UIC）、膳食碘摄入、碘过量