Original Article

Iodine status of Taiwanese children before the change in national salt iodization policy: a retrospective study of the nutrition and health survey in Taiwan 2001-2002

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Taiwan was an iodine deficiency area and endemic goiter was common in 1940's. Mandatory salt iodization started in 1967, and a 1971 survey indicated that goiter rates in children decreased from 21.6% to 4.3%. To understand iodine status before the change of national salt iodization program in 2003, from mandatory to voluntary salt iodization, we retrospectively measured urinary iodine concentrations of samples collected from children in the Nutrition and Health Survey in Taiwan 2001-2002. The median UI level for children aged 6-12 years was 123 µg/L (no differences between males and females). Females aged 10-12 years had the lowest urinary iodine levels. The percentages of this population with urinary iodine levels below 100, 50, and 20 µg/L were 35.2%±1.0%, 4.4%±0.4%, and 0.2%±0.1%, respectively. Older children were more likely to have low urinary iodine levels. People living in different areas of Taiwan had a median urinary iodine levels ranged from 113 µg/L to 164 µg/L (males: 113-153 µg/L; females: 105-174 µg/L), with the highest level in Penghu islands, and the lowest level in the eastern and southern (Southern area 2) areas. According to international criteria, iodine status in 2001-2002 was adequate, comparable to the surveyed goiter rates (4.3%, classified as iodine sufficiency) in 1971, inferring that iodine nutrition remained adequate and stable during this period. The present study is of great importance in documenting the iodine status of Taiwan before the change from mandatory to voluntary salt iodization to serve as a baseline data for future trend analysis in iodine nutrition.

Key Words: thyroid gland, iodine, iodized salt, nutrition surveys, Taiwan

INTRODUCTION

Iodine is an essential element of thyroid hormones, which are important to normal growth, development, and metabolism. When iodine intake is insufficient, the thyroid gland no longer produces adequate amounts of thyroid hormone, increasing the risk of iodine deficiency disorders (IDDs). In addition to goiter, hypothyroidism and cretinism, iodine deficiency also causes various degrees of brain damage, particularly during fetal and neonatal life.[1] Subtle mental deficiency, which reduces the learning capacity in children, is one of the important public health problems of concern. People living in areas of severe iodine deficiency may have an intelligence quotient (IQ) of up to 13.5 points lower than do those living in areas without iodine deficiency.[2] In a meta-analysis of 37 Chinese studies, children living in iodine-sufficient communities had an IQ 12.45 points higher than those living in iodine-deficient areas with no iodine supplementation, and 12.3 IQ points higher than those children with inadequate iodine supplementation during their mothers' pregnancies and after birth.[3] In the 1990s, the UN World Summit for Children set the goal of eliminating iodine deficiency via a universal salt iodization strategy recommended by the WHO and UNICEF. However, IDD remains the leading cause of preventable mental retardation worldwide.[4] During the last 10 years, iodine nutrition has steadily improved worldwide, and the number of countries with adequate iodine intake has increased from 67 to

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111.[5]

Taiwan is an island, and in the 1940s, endemic goiter was the fifth most common disease in Taiwan, with goiter rates of 18%, 44.7% and 61.1% in Japanese residents, Taiwanese, and indigenous people, respectively.[6-8] In 1958, a pilot study of salt iodization was conducted in selected high prevalence areas to prevent endemic goiter, and the goiter rate reduced from 51.3%±1% to 4.1%±0.3% for school children, and from 31.9%±1.1% to 12.8%±0.6% for other residents in the pilot areas 3 years after iodized salt administration.[9] The results were so encouraging that in 1967, the mandatory salt iodization program was extended to cover the entire population of Taiwan. To evaluate the effectiveness of salt iodization on endemic goiter, a national survey of thyroid enlargement in school children was conducted 4 years after the mandatory salt iodization program. Goiter rates decreased from 21.6% to 4.3%.[10] The program was continued until 2003 before the privatization of the Bureau of Salt Administration, a government-run monopoly company. During the past 40 years, there has been no national iodine nutrition survey, and little is known about the iodine status in Taiwan.

Because most iodine absorbed in the body is eventually excreted in the urine, measuring urinary iodine (UI) levels is a good indicator of very recent dietary iodine intake, and is commonly used in the assessment of iodine status in the population.[11-13] To understand the iodine status in Taiwan before the change of the salt iodization policy in 2003 to voluntary iodization, we retrospectively measured UI concentrations of samples obtained during the National Nutrition and Health Survey of Taiwan (NAHSIT) 2001-2002,[14] in which urine samples were collected from school children before the cessation of the mandatory salt iodization program.

METHODS

Study design

The NAHSIT was funded by the Food and Drug Administration, Department of Health, Taiwan to investigate the dietary and nutritional status of the population, and to estimate the prevalence of nutritional deficiencies, overnutrition, and related health conditions, as well as determinants of poor nutritional and health status. The NAHSIT 2001-2002 was a survey of Taiwan citizens aged between 6 and 13 years formally enrolled in elementary schools registered with the Ministry of Education. The NAHSIT 2001-2002 adopted a stratified two-stage sampling design. The study design and sampling procedures have been described previously.[14] In brief, 359 districts and townships in Taiwan were designated into 13 strata based on specific ethnic characteristics, geographic location, and population density. Data from the "Year 2000 Taiwan School Student Statistics" published by the Statistics Division of the Ministry of Education were used to determine population size and school selection. Eight schools were selected from each stratum, and 24 students (4 students from each grade) were randomly sampled from each school. A total of 2459 urine samples were collected and examined in the study. Informed consent was signed by one of the parents of all school children and the study was approved by the Department of Health in Taiwan.

Urine sample collection

Urine samples were collected after participants woke up in the morning and taken to the mobile health examination center. Aliquots of urine were stored immediately in liquid nitrogen and transported to Taipei within 2-3 days. Samples were then stored at -70 °C at the Academia Sinica (Taipei, Taiwan) until analysis.

Urinary iodine assay

UI measurements were performed in the Laboratory of Thyroid Disorders, Taipei Veterans General Hospital, Taiwan, in 2011. UI was assayed by the microplate method based on the Sandell-Kolthoff (S-K) reaction using ammonium persulfate as the oxidizing agent with modifications.[15-18] In brief, the digestion step was performed by pipetting 25 μL of standard iodine solutions and urine samples into the 96-well reaction plate (Applied Biosystems, Foster City, CA, USA), followed by adding 50 μL of ammonium persulfate solution (freshly made, 1.35 mol/L; Sigma-Aldrich, St. Louis, MO, USA) to each well. The microplate was covered with a 96-well full plate cover and digested in the GeneAmp® PCR System 9700 Fast Thermal Cycler (Applied Biosystems) with a program of 95 °C for 30 mins and 4 °C for 5 mins. After digestion, the microplate was centrifuged at 1000 rpm for 3 mins. The S-K reaction step as previously described[17] was then carried out. Fifty μL aliquots of the resulting digests were transferred to the corresponding wells of a 96-well reading plate (MicroWell®; Nalge Nunc International, Rochester, NY, USA), in which 100 μL of arsenious acid solution (0.05 mol/L; Sigma-Aldrich) had been preloaded. After mixing the solution by shaking the plate in the microplate reader (Tecan Infinite® F50; Tecan Group Ltd., Männedorf, Switzerland), 50 μL of ceric ammonium sulfate solution (0.019 mol/L; Wako Pure Chemical Industries Ltd, Osaka, Japan) was added into each well using a multichannel pipette as quickly as possible. The absorbance of the reaction mixture was read at 405 nm after incubating at room temperature (~25 °C) for 30 mins. The calibration curve was prepared for each plate by plotting optical density values versus the concentration of standards. Sample concentrations were interpolated from the calibration curve. Pooled urines with low, medium and high iodine concentrations, and potassium thiocyanate/L-ascorbic acid (final concentration 50 mmol/L) were included in each plate as internal controls to verify the accuracy of the assay and that digestion had been successful. External quality control samples were provided by the Ensuring the Quality of Urinary Iodine Procedures (EQUIP) program and were tested three times a year to ensure the quality of UI measurements. All samples were analyzed in duplicate for two runs. Samples with readings >400 μg/L were diluted with water to fit the calibration curve. Measurement was repeated for samples with discordant duplicate values exceeding 15%. The intra- and inter-assay coefficient of variation values were <10% at iodine concentrations >20 μg/L.

Data analysis

The iodine status was expressed as the median UI concen-

Table 1. Urinary iodine levels (μg/L) of samples from the National Nutrition and Health Survey of Taiwan 2001-2002[14] by age, gender and geographic area

	Total		Males		Females	
	Median	95%CI	Median	95%CI	Median	95%CI
Age						
6-12 years	123	121-125	123	120-126	123	120-126
6-7 years	155	150-160	156	142-170	150	134-167
7-8 years	127[†]	122-132	133	120-145	119	104-134
8-9 years	122[†]	117-127	114[§]	102-127	131	116-146
9-10 years	125[†]	120-130	124[§]	110-138	131	117-145
10-11 years	109[†,‡]	104-114	114[§]	102-125	100[‖,¶,#]	89-112
11-12 years	110[†,‡]	106-114	113[§]	103-124	102[‖,¶,#]	90-114
Strata						
Northern area 1	114[**]	107-121	116[††]	101-132	105	81-129
Northern area 2	135	128-142	142	126-158	129	105-153
Northern area 3	120[**]	114-126	121	101-141	118	103-134
Central area 1	118[**]	110-126	114[††]	94-135	122	98-145
Central area 2	126[**]	119-133	124	105-142	132	113-152
Central area 3	125[**]	118-132	126	107-145	122[‡‡]	99-145
Southern area 1	131[**]	124-138	116[††]	97-136	141	123-158
Southern area 2	113[**]	107-119	114[††]	99-130	111[‡‡]	93-129
Southern area 3	131[**]	124-138	131	114-147	131	111-151
Eastern area	113[**]	106-120	118[††]	95-141	112[‡‡]	95-129
Hakka area	120[**]	112-128	120	96-144	119[‡‡]	100-139
Penghu islands	164	156-172	153	132-174	174	149-199
Mountain area	123[**]	116-131	113[††]	92-135	133	112-153

[†] *vs* children 6-7 years, $p< 0.05$; [‡] *vs* children 7-8 years, $p<0.05$; [§] *vs* males 6-7 years, $p<0.05$; [‖] *vs* females 6-7 years, $p<0.05$; [¶] *vs* females 7-8 years, $p<0.05$; [#] *vs* females 8-9 years, $p<0.05$; [**] *vs* children in Penghu, $p<0.05$; [††] *vs* males in Penghu, $p<0.05$; [‡‡] *vs* females in Penghu, $p<0.05$.

tration for the sampled population. The criteria for classifying iodine nutrition of a population proposed by WHO/UNICEF/International Council for Control of Iodine Deficiency Disorders (ICCIDD) are as follows: <20 μg/L as severe iodine deficiency; 20-49 μg/L as moderate iodine deficiency; 50-99 μg/L as mild iodine deficiency; 100-199 μg/L as adequate iodine nutrition; 200-299 μg/L as above requirements; and ≥300 μg/L as excessive. In addition, not more than 20% of population should have levels below 50 μg/L.[19]

Descriptive statistics and hypothesis testing were analyzed using SAS 9.2. The data is expressed as the median±SE. The significance of variation among various statuses was evaluated by Kruskal-Wallis test and multiple comparison (Dunn's test). The trend of changes in specific variables among age groups was analyzed using the chi-squared test for trend. Significance was taken as $p<0.05$.

RESULTS

As shown in Table 1, the median UI level for the Taiwanese population aged 6-12 years was 123 μg/L (95% CI 121-125). Both females and males had the same median UI levels of 123 μg/L. The median UI levels of different age groups ranged from 109 to 155 μg/L. Young children (aged 6-7 years) had a higher median UI level than old children (11-12 years) for both males ($p<0.05$) and females ($p<0.05$). The lowest median UI level was found in females of 10-12 years old which was just above the lower limit of adequate iodine nutrition. As shown in Table 2, the population with UI levels <100, <50, and <20 μg/L was 35.2%±1.0%, 4.4%±0.4%, and 0.2%±0.1%, respectively. The percentage of mild and moderate iodine insufficiency (<100 and <50, respectively) appeared to increase with age ($p<0.001$), reaching a peak at 10-11 and 11-12 years, respectively. Females had a slightly higher percentage of UI levels of <100 μg/L, <50 μg/L and <20 μg/L than males, which was more noticeable in the 10-12 years age groups.

The distribution of UI levels in school children according to the classification of iodine nutrition proposed by WHO/UNICEF/ICCIDD is shown in Table 3. The overall percentage of children with UI levels 100-199 μg/L was 45.9% (48.4% and 43.2% for males and females, respectively). Of the 35.2% of the study population defined as having insufficient iodine nutrition, 30.8% were defined as mild, <5% as moderate and only 0.2% as severe. Males had a higher percentage of adequate iodine nutrition than females in the 7-8 and 10-12 years age groups, but a lower percentage than females at 8-9 years which was due to the left shift of UI distribution resulting in an increase in mild iodine deficiency. The percentage of children with excessive iodine nutrition was 6.8%, and was similar in both sexes. The percentage of excessive iodine nutrition was generally higher in younger children than in older children for both sexes.

As shown in Table 1, people living in different areas of Taiwan had median UI levels ranging from 113 μg/L to 164 μg/L (Table 1). The highest median UI level (including both males and females) was in the Penghu Islands, and the lowest level was in Eastern area and Southern area 2. The mountain area had median UI level similar to the plain areas. The median UI levels of males and females in 13 strata surveyed were 113-153 μg/L and

Table 2. Distribution of urinary iodine levels <100 μg/L, <50 μg/L and <20 μg/L in samples from the National Nutrition and Health Survey of Taiwan 2001-2002[14] by age and gender

Sample (n)		Age (years) 6-12	6-7	7-8	8-9	9-10	10-11	11-12	*p* for trend*
		2459	414	405	413	414	416	397	
Population <20 μg/L									
Total	Percent (%)	0.17	0.01	0.07	0	0.04	0.33	0.58	-
	SE	0.07	0.05	0.13	0	0.10	0.28	0.27	-
Male	Percent (%)	0.01	0.02	0	0	0.08	0	0	-
	SE	0.03	0.08	0	0	0.19	0	0	-
Female	Percent (%)	0.34	0	0.15	0	0	0.70	1.25	-
	SE	0.15	0	0.28	0	0	0.62	0.56	-
Population <50 μg/L									
Total	Percent (%)	4.4	1.9	2.9	3.7	6.6	4.8	6.7	0.0004
	SE	0.41	0.67	0.83	0.93	1.22	1.05	1.25	
Male	Percent (%)	4.1	1.7	2.5	4.5	8.4	3.6	3.8	0.0668
	SE	0.54	0.86	1.05	1.37	1.88	1.22	1.37	
Female	Percent (%)	4.8	2.1	3.3	2.9	4.6	6.0	9.9	0.0017
	SE	0.63	1.07	1.30	1.23	1.50	1.77	2.12	
Population <100 μg/L									
Total	Percent (%)	35.2	21.1	32.7	35.8	34.5	44.4	42.7	<0.0001
	SE	0.96	2.01	2.32	2.36	2.34	2.44	2.49	
Male	Percent (%)	33.1	27.2	27.2	38.8	34.2	39.4	38.4	<0.0001
	SE	1.29	2.69	3.00	3.23	3.21	3.20	3.47	
Female	Percent (%)	37.5	21.1	39.0	32.7	34.8	50.0	47.5	<0.0001
	SE	1.44	3.02	3.56	3.47	3.42	3.72	3.54	

The trend analysis is not performed in the population with urinary iodine concentration < 20 μg/L due to small sample size.

Table 3. Iodine status of samples from the National Nutrition and Health Survey of Taiwan 2001-2002[12] by age and gender, according to WHO/UNICEF/ International Council for Control of Iodine Deficiency Disorders criteria

Age (years)	Sample (n)	Insufficient: Severe <20 μg/L (%)	Insufficient: Moderate 20-49 μg/L (%)	Insufficient: Mild 50-99 μg/L (%)	Adequate 100-199 μg/L (%)	UI ≥200 μg/L: Above require 200-299 μg/L (%)	UI ≥200 μg/L: Excessive ≥300 μg/L (%)
Total							
6-12	2459	0.17	4.22	30.8	45.9	12.2	6.76
6-7	414	0.01	1.90	19.1	49.2	19.3	10.5
7-8	405	0.07	2.78	29.9	47.9	11.9	7.47
8-9	413	-	3.66	32.1	44.7	12.8	6.72
9-10	414	0.04	6.51	28.0	44.1	14.2	7.13
10-11	416	0.33	4.43	39.7	43.3	7.10	5.17
11-12	397	0.58	6.08	36.0	46.2	7.59	3.59
Male							
6-12	1328	0.01	4.04	29.1	48.4	12.2	6.33
6-7	231	0.02	1.70	19.3	48.7	18.8	11.4
7-8	218	-	2.47	24.7	56.0	11.4	5.44
8-9	229	-	4.45	34.3	40.5	14.0	6.75
9-10	219	0.08	8.34	25.8	44.4	15.3	6.13
10-11	234	-	3.63	35.8	48.1	7.32	5.13
11-12	197	-	3.81	34.5	52.1	6.53	3.08
Female							
6-12	1131	0.34	4.43	32.7	43.2	12.1	7.24
6-7	183	-	2.13	19.0	49.7	19.8	9.44
7-8	187	0.15	3.12	35.7	38.8	12.5	9.77
8-9	184	-	2.85	29.8	49.2	11.5	6.66
9-10	195	-	4.55	30.3	43.8	13.1	8.19
10-11	182	0.70	5.33	44.0	38.0	6.84	5.20
11-12	200	1.25	8.66	37.6	39.5	8.79	4.17

105-174 μg/L, respectively. The lowest median UI level for males and females was in Mountain area and Northern area 1, respectively. The highest percentage of males and females with mild iodine deficiency was observed in Hakka area (37.2%) and Northern area 1 (43.9%), respectively. However, the overall percentage of males and females with UI levels <100 μg/L was less than 50%, and less than 20% of children surveyed had UI levels <50 μg/L across all strata.

DISCUSSION

Endemic goiter was once common in Taiwan, but a survey in 1971 demonstrated that the implementation of the mandatory salt iodization program in 1967 had successfully reduced the goiter rate in school children from 21.6% to 4.3%.[10] According to the classification of iodine status based on the prevalence of goiter in school-aged children proposed by the WHO,[19] the iodine status of Taiwan was classified as sufficient in 1971. Although the national salt iodization program continued until the privatization of the Bureau of Salt Administration in 2004, there has been no national survey of iodine nutrition for the past 40 years. This retrospective study, providing data on UI levels collected during the NAHSIT 2001-2002,[14] will be of great importance in understanding the iodine status of Taiwan before the change of mandatory to voluntary salt iodization. It also provides baseline UI data that can be used to evaluate the trends in iodine nutrition after the cessation of mandatory salt iodization program.

After the introduction of salt iodization, the goiter rates of school children in Taiwan dropped dramatically to 4.3%. The reduction ratio of goiter rate was 1.4% in non-endemic area and 85.1% in hyperendemic area. The dramatic reduction of goiter rate in hyperendemic area suggested that iodine deficiency was the major factor underlying endemic goiter in Taiwan.[10] The median UI level in school children in the present study was 123 μg/L, and the percentage of children with UI levels <50 μg/L was 4.4%, indicating that the iodine status of Taiwan's population in 2001-2002 was adequate. The results are comparable to the goiter rate of 4.3% (<5% defined as iodine sufficiency by WHO criteria) observed in school children in 1971. It is reasonable to infer that the iodine nutrition in the population remained adequate and stable during this 30-year period (1971-2002), which is believed to be attributable to the sustaining mandatory salt iodization in Taiwan from 1967 to 2003. In the early years of salt iodization, there was still a >5% goiter rate surveyed in the hyperendemic areas (7.5% in males and 10.4% in females).[10] The reduction of thyroid size usually responds to salt iodization with a lag interval varying from months to years. Therefore, populations might have attained iodine sufficiency without demonstrating significant goiter reduction early in salt iodization.[19] The median UI levels across all strata in NAHSIT 2001-2002 were ≥113 μg/L, suggesting that the >5% goiter rate in hyperendemic areas 4 years after salt iodization was probably because of the slow recovery of thyroid size rather than persistent iodine deficiency in these areas.

In the 1971 survey, goiter rates were higher in females than males before salt iodization, and the reduction in goiter rates was slightly lower in females (from 27.0% to 6.1%; reduction ratio 77.5%) than in males (from 20.7% to 4.0%; reduction ratio 80.6%).[9,10] In 2000-2002, the median UI levels were 123 μg/L in both males and females, which was comparable to the goiter rate in males of 4.01% in the 1971 survey, and showed some improvement in females (6.1%). This improvement was probably due to the slow recovery of thyroid enlargement after salt iodization, or the socioeconomic changes associated with an increase in dietary iodine nutrition in females during the 30-year period.

By analyzing the reduction ratio of goiter rates (the difference of goiter rate before and after salt iodization divided by the goiter rate before salt iodization) in different age groups in males and females in 1971, a higher goiter rate and a lower reduction ratio were found in older children (particularly females) in the same endemic areas after salt iodization. In the present study, we observed that children aged 6-7 years had a higher median UI level (155 μg/L) than those aged 11-12 years (110 μg/L), and females aged 10-12 years had a lower UI levels (100-102 μg/L) than males of same age group (113-114 μg/L). In addition, a higher percentage of girls than boys in the 10-12-year age group had a UI <100 μg/L (47.5%-50% vs 38.4%-39.4%). This finding is consistent with the goiter rate in the previous survey, suggesting that a difference in iodine nutrition does exist between ages and sexes.[10] This difference cannot be solely explained by dietary variations, and it might be related to different physiological requirements for thyroxine for physical growth between young and older children, as well as the different age of onset of sexual maturation between boys and girls. Although the overall iodine status of school girls in Taiwan is adequate, median UI levels in the 10-12-year age groups were on the borderline of iodine sufficiency. This raises the question whether the UI levels of high-school girls or young women will fall below 100 μg/L. Pregnant women require a higher iodine intake because of increased renal clearance of iodine and transfer of iodine to the fetus, and therefore this group is vulnerable to iodine deficiency.[20] The criteria for iodine sufficiency in pregnant women are much higher than in non-pregnant women, and UI levels of 150-249 μg/L are considered to be optimal.[19] Young women might proceed to pregnancy in the short-to-medium term and are often unaware of the pregnancy during the early weeks of gestation and therefore not taking additional iodine supplementation. Preliminary evidence suggests that even mild iodine deficiency during pregnancy causes adverse effects on fetal neurocognition, which are not corrected by iodine sufficiency during childhood.[20] The present median UI levels of school girls put them at some risk of iodine deficiency during a future pregnancy. Further evaluation of iodine nutrition in women of reproductive age, and during pregnancy and breastfeeding, is an important issue to prevent brain damage in fetuses and neonates.

In the 13 strata surveyed in Taiwan, the median UI levels were all above 113 μg/L. The Penghu Islands are groups of small islands located at northwest of Taiwan, where diets are rich in seaweed and seafood. As expected, the median UI levels of boys and girls on the Penghu Islands are the highest among all strata, in accordance with the previous report that no ≥ grade II thyroid enlargement was observed in school children living in the Penghu Islands. On the contrary, mountain areas had high goiter rates in the past but achieved iodine sufficiency with UI levels similar to the plain areas after the national salt iodization program. Taiwan achieved sufficient iodine status following the national salt iodization program started in 1967. However, this beneficial step was not supported by periodic evaluation of iodine status in the population, or any adjustment of the program to adapt to the changing social context in the following years. Over time, a lack of awareness of iodine nutrition by the public, civic and academic sectors has developed. This is the first nationwide report on UI status in Taiwan, more than 30 years since the last survey. By the time the iodine status data from NAHSIT 2001-2002 were available, the mandatory salt iodization policy had ceased in 2004. The increase in non-iodized salt on the market, the increased consumption of processed food, and the global push towards a low-sodium diet to prevent cardiovascular diseases in recent years might negatively influence the iodine status in the population. There is a need for a comprehensive investigation of iodine status and implementation of new evidence-based iodine policy to avoid deterioration of iodine nutrition, particularly in vulnerable populations such as pregnant women and neonates.

In conclusion, historically, the iodine status of Taiwan was moderately deficient. The mandatory salt iodization program successfully corrected iodine deficiency as demonstrated in the 1971 survey, and iodine sufficiency had been maintained in 2000-2002. The results support that salt iodization is a simple and cost-effective method to eliminate IDDs, and the data also indicate that the major source of dietary iodine in Taiwan (except in the Penghu Islands) is iodized salt. Although the overall median UI level of school children is adequate, there is risk of iodine deficiency in particular populations, such as pregnancy women and neonates. The combination of the change from mandatory to voluntary salt iodization and changing dietary habits might alter iodine status in the Taiwanese population. Close monitoring of changes in iodine status and the development of policies on iodine nutrition are important in the prevention of IDDs.

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AUTHOR DISCLOSURES
Nothing to declare.

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Original Article

Iodine status of Taiwanese children before the change in national salt iodization policy: a retrospective study of the nutrition and health survey in Taiwan 2001-2002

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台灣學童在國家食鹽加碘政策變更前的碘營養狀況：台灣 2001-2002 營養健康調查之回顧性研究

過去台灣是屬於缺碘地區，地方性甲狀腺腫在 1940 年代時十分流行。台灣自 1967 年開始實施強制性食鹽加碘以來，學童的甲狀腺腫大率由當時的 21.6%降至 1971 年的 4.3%。為瞭解國家食鹽加碘政策，在 2003 年從強制改為自願加碘前的碘營養狀況，我們回顧性檢測 2001-2002 台灣學童營養健康調查所收集尿液標本的碘濃度。發現 6-12 歲學童的尿碘中位數是 123 微克/升(男女沒有差異)，當中以 10-12 歲女生的尿碘濃度最低。學童尿碘濃度低於 100、50 和 20 微克/升的人口百分比分別是 35.2% ± 1.0%、4.4% ± 0.4%和 0.2% ± 0.1%，年紀較大的學童尿碘濃度較容易偏低。台灣各地區層的學童尿碘中位數介於 113 微克/升至 164 微克/升之間 (男生 113 - 153 微克/升；女生 105 - 174 微克/升)，當中最高是澎湖，最低是東部層和南二層。根據國際標準，台灣在 2001-2002 年時的碘營養狀況是足夠的，相較於 1971 年時的甲狀腺腫大率 4.3% (定義為碘足夠)，並無多大差別，推測這段期間台灣的碘營養維持正常和穩定。本研究記錄台灣食鹽加碘政策從強制改為自願加碘前的碘營養狀況，提供日後碘營養變化、趨勢分析和比較極為重要的基礎數據。

關鍵字：甲狀腺、碘、加碘鹽、營養調查、台灣