Iodine nutritional status of lactating women in northern Taiwan in 2019

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Abstract

Background: Pregnant and lactating women are vulnerable to iodine deficiency. This study was conducted to evaluate the iodine nutritional status of lactating women in northern Taiwan.

Methods: Women recruited from Taipei Veterans General Hospital (TVGH) in 2019 provided a spot urine sample and completed a Food Frequency Questionnaire. The urinary iodine concentration (UIC) was measured by inductively coupled plasma mass spectrometry.

Results: The overall median UIC in 198 women was 120.4 μg/L, indicating a sufficient iodine status. Univariate analysis revealed a lower median UIC in women of younger age ($p = 0.004$), who were not taking multivitamins ($p = 0.004$), not on a postpartum nourishment diet ($p = 0.04$), and whose infant received more breast milk ($p = 0.004$). The median UIC was <100 μg/L in the group aged 20 to 29 years (UIC: 74.4 μg/L) and in women whose infants' diet was composed of >50% breast milk (UIC: 86.1 μg/L). A postpartum nourishment diet was followed by 73.7% (n = 146) of the women. Nevertheless, a significant decrease in the intake frequency of iodine-containing foods, including seaweeds ($p < 0.001$), seafood ($p < 0.001$), dairy products ($p = 0.009$), and multivitamins ($p < 0.001$) was observed compared with the intake noted in a previous survey of pregnant women in TVGH. Following multivariate analysis, only younger age (20-29 vs ≥30 years; odds ratio [OR]: 3.38; 95% confidence interval [CI]: 1.49-7.65), no use of multivitamin (OR: 1.89; 95% CI: 1.03-3.48), and infant diet composition (>50% breast milk vs <50% breast milk; OR: 2.93; 95% CI: 1.37-6.25) were independently associated with UIC < 100 μg/L.

Conclusion: The results suggest that the iodine status in lactating women in northern Taiwan is adequate. However, iodine deficiency may continue to be present in certain subgroups, such as women of younger age and those who do not take multivitamins.

Keywords: Iodine; Lactation; Taiwan

1. INTRODUCTION

Iodine, an essential micronutrient, is vital for the production of thyroid hormone, normal growth, and neurodevelopment.[1] Infants are particularly sensitive to iodine deficiency because only small amounts of iodine are stored in their thyroids and they have a relatively high iodine requirement considering their low body weight. In addition, pregnant and lactating women are considered vulnerable groups for iodine deficiency because they supply the fetuses and infants with iodine during a critical period of brain maturation.[2–5] To meet the increased demand of iodine nutrition during pregnancy and lactation, the World Health Organization recommends a daily iodine intake of 250 μg for both pregnant and lactating women, which is 100 μg higher than the usual recommended daily intake for adults.[6]

Taiwan currently endorses a voluntary salt iodization strategy and has undergone periods of iodine sufficiency and mild deficiency in response to changes in salt trading.[7–9] The median urinary iodine concentration (UIC) in individuals aged 6 years or older in the Nutrition and Health Survey in Taiwan in 2013 was 96 μg/L, indicating mild iodine deficiency (the criterion for iodine

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sufficiency in those aged 6 years or older is a median UIC ranging from 100 to 299 μg/L).[9] A national survey of pregnant women in Taiwan in 2017-2019 also suggested mild iodine deficiency with a median UIC of 148 μg/L (the criterion for iodine sufficiency during pregnancy is a median UIC ranging from 150 to 249 μg/L).[10] In our study of pregnant women in an urban area of northern Taiwan in 2018, the median UIC was 225.3 μg/L, which infers adequate iodine nutrition.[11] After delivery, women in Taiwan usually live in a postpartum care center or have specialized personnel take care of them at home for 15 to 45 days. It is part of the ethnic Chinese culture for women to receive postpartum care and a postpartum nourishment diet. Previous studies evaluating the iodine nutritional status in pregnant women in Taiwan did not include postpartum lactating women; this group may have very different sources of iodine intake.[10–12] The aim of this study was to determine the iodine nutritional status of lactating women in northern Taiwan and investigate their dietary sources of iodine.

2. METHODS

2.1. Study design

This cross-sectional survey involved postpartum lactating women who delivered their babies in Taipei Veterans General Hospital (TVGH). Women aged ≥20 years who were lactating at the time of recruitment were eligible for entry in this study. The recruitment period was initiated in January and ended in December 2019. Each participant provided a random spot urine sample and completed a simple Food Frequency Questionnaire (FFQ). The study was approved by the local Institutional Review Board of TVGH (IRB No: 2016-02-007BC). Written informed consent was provided by each woman before participation.

2.2. Urinary iodine analysis

All urine samples were analyzed in triplicate using the Agilent 7700 Series inductively coupled plasma mass spectrometer.[11] The mean values of the triplicate analyses were calculated. Sample concentrations were interpolated from a urine calibration curve (standard curve), and readings >1000 μg/L were diluted to fit the calibration curve. The detection limit was 1 μg/L. Quality control samples provided by the Ensuring the Quality of Urinary Iodine Procedures (EQUIP) program were used in each run to ensure the accuracy of measurements.

2.3. FFQ

The FFQ was similar to that previously used in our study of pregnant women.[11] It contained questions surveying the frequency (ie, 1, 3, 5, 7 days/wk, or never) of consumption of iodine-containing foods (ie, seaweed, fish, seafood [except fish], dairy products, and multivitamins). Participants also identified the brands of multivitamins they received and vendors of their postpartum nourishment diet. This was achieved by viewing an illustrated sheet of images of multivitamins available in the market and logos of the vendors of postpartum nourishment diets. Finally, we inquired about the breastfeeding condition and the percentage of breast milk/formula milk their babies received.

2.4. Statistical analysis

UICs and intake frequencies are presented as the median with the interquartile range (IQR), whereas the other variables are expressed as the mean ± SD or the number with percentages. The Kolmogorov-Smirnov test revealed that UICs and intake frequencies were not normally distributed. Hence, nonparametric tests, including the Mann-Whitney *U* test (for two-group comparisons) and the Kruskal-Wallis test with Dunn's post hoc tests (for three-group comparisons), were selected to assess the differences between the continuous variables. Pearson's chi-squared test was used for comparisons between categorical variables. The significant variables identified in the bivariate analysis were included in a multivariate logistic regression model to determine the risk factors for UIC < 100 μg/L. To assess the changes in dietary habits from pregnancy to postpartum, the data obtained from the FFQ in the current study were compared with previously published results for pregnant women in TVGH.[11] All data analyses were performed using the Statistical Package for the Social Sciences (SPSS) software, version 26.0 (IBM Corp., Armonk, NY, USA). A two-tailed p value of <0.05 denoted a statistically significant difference.

3. RESULTS

Among the 198 studied women, 74% (n = 147) were recruited shortly after delivery in the hospital ward and the other 26% (n = 51) were enrolled when they returned to the outpatient clinic for a postpartum checkup. The mean age of the women was 33.6 ± 4.2 years (range: 22-44 years) and the time of enrollment was 13.6 ± 22.1 days postpartum (range: 0-146 days).

3.1. UIC

The median UIC in these women was 120.4 μg/L (IQR: 64.6-235.3 μg/L), and the overall distribution of UIC revealed that 40.4%, 17.6%, and 3.0% of them had an UIC <100, <50, and <20 μg/L, respectively (Table 1).

When the iodine status was analyzed according to patient demographics, we found that age was statistically and significantly associated with the median UIC (UIC: 74.4, 120.4, and 148.6 μg/L for women aged 20-29, 30-34, and 35-44 years, respectively; $p = 0.004$) and UIC distribution (UIC < 100 μg/L: 64.7%, 40.5%, and 30%, respectively; $p = 0.003$). There were no statistically significant differences in UIC observed among women in relation to the region of residence, body mass index, educational status, and other obstetrical variables (eg, maternal miscarriage history, birth parity, fetal birth weight, or term levels) (Table 1).

3.2. Dietary habits

According to the FFQ, the most commonly consumed iodine-containing foods in the studied women were fish and dairy products; 69.2% and 68.2% of the women reported that they consumed these foods ≥3 days/wk. Seafood and seaweeds appeared on the dining table ≤3 days and ≤1 day/wk, respectively (Table 2). A total of 146 women (73.7%) received some type of postpartum nourishment diet, and 117 women (59.1%) were consuming the postpartum diet provided by TVGH at the time of study entry. When household use of iodized salt was surveyed, 26.3% (n = 52) of the studied women could not recall the brand or type of salt used at home, whereas another 2.5% (n = 5) did not use salt at home. Based on the data provided by those with clear information on salt brand/type (n = 141), we found that 82.3% (n = 116) of the products were iodized, whereas the remaining 17.7% (n = 25) were not.

Compared with the older age group (30-44 years), the younger age group (20-29 years) consumed less fish ($p = 0.034$) and fewer women of that group were on a postpartum nourishment diet ($p = 0.030$) (Table 3). When their dietary habits were compared with those previously reported in our survey of pregnant women in 2018, we found a statistically significant decrease in the intake frequency of iodine-containing foods, including seaweeds ($p < 0.001$), seafood ($p < 0.001$), and dairy products ($p = 0.009$) (Table 4).

3.3. Multivitamin intake

Overall, 27.8% of the studied women took one multivitamin tablet per day, 21.2% took multivitamins less frequently, and 51.0% never took multivitamins (Table 2). The frequency of

Table 1

Urinary iodine concentration and its distributions

	Urinary iodine concentration, μg/L				
	Median (IQR)	*p*	<100	≥100	*p*
Total (n = 198)	120.4 (64.6-235.3)		40.4	59.6	
Age, y		0.004			0.003
20-29 (n = 34)	74.4 (44.8-140.0)		64.7	35.3	
30-34 (n = 84)	120.4 (65-232.1)[a]		40.5	59.5	
35-44 (n = 80)	148.6 (75.3-277.1)[b]		30.0	70.0[c]	
Residing region		0.855			0.983
Metropolis (n = 131)	121.1 (65.8-233.6)		40.5	59.5	
Suburb (n = 67)	118.2 (56.3-253.4)		40.3	59.7	
Educational status		0.676			0.359
University or below (n = 157)	118.2 (65.0-224.8)		42.0	58.0	
Master or above (n = 41)	139.1 (56.6-265.3)		34.1	65.9	
BMI, kg/m^2		0.904			0.126
<27 (n = 139)	119.6 (58.4-245.1)		43.9	56.1	
≥27 (n = 59)	121.1 (66.8-194.7)		32.2	67.8	
Birth body weight, g		0.431			0.802
<2500 (n = 23)	154.1 (64.9-294.3)		34.8	65.2	
2500-3500 (n = 150)	121.1 (63.9-236.4)		40.7	59.3	
≥3500 (n = 25)	113.5 (57.4-181.9)		44.0	56.0	
Miscarriage history		>0.99			0.682
Yes (n = 66)	118.2 (63.4-239.4)		42.4	57.6	
No (n = 132)	122.7 (63.7-236.9)		39.4	60.6	
Full-term birth		0.428			0.109
Yes (n = 115)	124.7 (67.3-230.5)		35.7	64.3	
No (n = 83)	109.1 (56.6-239.0)		47.0	53.0	
Birth parity		0.061			0.651
First (n = 125)	119.0 (66.1-249.1)		39.2	60.8	
Second or above (n = 73)	121.1 (55.6-234.8)		42.5	57.5	
Postpartum nourishment diet		0.039			0.740
Yes (n = 146)	122.6 (63.9-242.1)		41.1	58.9	
No (n = 52)	116.9 (60.0-201.8)		38.5	61.5	
Multivitamin intake		0.004			0.018
Yes (n = 97)	143.2(82.6-283.5)		32.0	68.0	
No (n = 101)	102.6 (46.6-196.9)		48.5	51.5	
Infant diet composition		0.004			0.021
>50% breast milk (n = 68)	86.1 (46.6-189.9)		52.9	47.1	
50% formula milk (n = 57)	118.2 (65.0-227.4)		38.6	61.4	
<50% breast milk (n = 73)	154.1 (80.8-293.4)[d]		30.1	69.9[e]	
Salt intake		0.944			0.788
Noniodized (n = 25)	103.8 (70.6-179.0)		44.0	56.0	
Iodized (n = 116)	123.5 (62.3-241.3)		38.8	61.2	
Unknown (n = 52)	121.8 (65.3-273.9)		40.4	59.6	
Do not ingest salt (n = 5)	69.4 (28.1-21 027.5)		60.0	40.0	

IQR = interquartile range.
[a]$p = 0.050$ vs age 20-29 y.
[b]$p = 0.003$ vs age 20-29 y.
[c]$p < 0.05$ vs age 20-29 y.
[d]$p = 0.002$ vs >50% breast milk.
[e]$p < 0.05$ vs >50% breast milk.

multivitamin intake was significantly decreased in lactating women compared with the pregnant women in our previous survey (median 0 vs 7 days, respectively; $p < 0.001$) (Table 4).

When the types of multivitamins taken were surveyed, 16 women could not recall relevant information on the brand name and iodine content of the multivitamins they consumed. According to the data provided by those with clear information on brand name and iodine content (n = 81), 91.4% (n = 74) of the ingested multivitamin products contained iodine, whereas the remaining 8.6% (n = 7) were iodine-free. One, four, and 69 women took a multivitamin product containing 250 μg, 75 μg, and 100 to 150 μg of iodine, respectively.

3.4. Breast milk and infant diet composition

Mothers for whom the breast milk composed >50% of the infant diet had a lower UIC than those whose babies were fed with more formula milk (UIC: 86.1, 118.2, and 154.1 μg/L for infant diet compositions: >50% breast milk, 50% breast milk, and <50% breast milk, respectively; $p = 0.004$) (Table 1).

3.5. Multivariate analysis

Multivariate analysis revealed that women who were younger (age 20-29 vs ≥30 years; odds ratio [OR]: 3.38; 95% confidence

Table 2

Food Frequency Questionnaire: number of days per week in consumption

Food type	0, %	1 d, %	3 d, %	5 d, %	7 d, %	Median (IQR)
Seaweed	52.5	37.4	9.6	0.5	0	0 (0-1)
Fish	7.6	23.2	49.5	8.6	11.1	3 (1-3)
Seafood (except fish)	39.4	30.3	28.8	0.5	1.0	1 (0-3)
Dairy products	15.7	16.2	26.3	7.6	34.3	3 (1-7)
Multivitamin	51.0	4.0	11.6	5.6	27.8	0 (0-7)

IQR = interquartile range.

Table 3

Between-group comparison of dietary habits according to age

Variables/age, y	20-29 (n = 34)	30-44 (n = 164)	*P*
Postpartum nourishment diet eater	20 (58.8)	126 (76.8)	0.030
Multivitamin user	13 (38.2)	84 (51.2)	0.168
Infant diet composition			0.210
>50% breast milk	16 (47.1)	52 (31.7)	
50% formula milk	7 (20.6)	50 (30.5)	
<50% breast milk	11 (32.4)	62 (37.8)	
Food intake frequency, d/wk			
Seaweed	0 (0-1)	0 (0-1)	0.268
Fish	2 (1-3)	3 (1-3)	0.034
Seafood (except fish)	1 (0-3)	1 (0-3)	0.348
Dairy products	3 (1-7)	3 (1-7)	0.938
Multivitamin	0 (0-6.5)	1 (0-7)	0.303

Values are expressed as the n (%) or median (IQR).
IQR = interquartile range.

interval [CI]: 1.49-7.65; $p = 0.004$) and did not consume multivitamins (OR: 1.89; 95% CI: 1.03-3.48; $p = 0.041$) or who fed their baby more breast milk (infant diet: >50% breast milk vs <50% breast milk; OR: 2.93; 95% CI: 1.37-6.25; $p = 0.005$) were at increased odds of having a UIC <100 μg/L (Table 5).

4. DISCUSSION

We investigated the iodine nutritional status of lactating women who delivered their babies in a medical center in northern Taiwan. The overall median UIC of the surveyed women was 120.4 μg/L. However, the median UIC was <100 μg/L in women aged 20 to 29 years and whose infants were fed with more breast milk than formula milk. The results indicate that iodine nutrition is adequate in general; nevertheless, iodine deficiency may continue to be present in certain subgroups. For individuals aged ≥6 years, iodine sufficiency was suggested when the percentage of the population with UIC <100 and <50 μg/L did not exceed 50% and 20%, respectively.[6] Currently, there are no criteria for the distribution of UIC in lactating women. However, the percentages of women with UIC <100 μg/L (40.4%) and <50 μg/L (17.6%) in this study did not violate the criteria for adults.

In lactating women, absorbed dietary iodine is partitioned by the thyroid, kidney, and mammary secretory epithelium. Iodine is concentrated into the thyroid and mammary gland milk through the sodium iodide symporter under regulation by prolactin and other hormones.[13] The possible loss of iodine from breastfeeding may somewhat explain the observed association between the variable "infant diet composition > 50% breast milk" and low UIC in this study. During breastfeeding, there is obligatory passive glomerular filtration of iodine into the urine with a constant excretion rate of 67%, even under iodine deficiency.[14]

Table 4

Comparison of dietary habits between lactating and pregnant women

	Lactating women	Pregnant women[a]	*P*
Age (SD)	33.6 (4.2)	33.9 (4.3)	0.399
Residing area, %			0.860
Metropolis	131 (66.2)	168 (65.4)	
Suburb	67 (33.8)	89 (34.6)	
Food intake frequency (IQR)			
Seaweed	0 (0-1)	1 (1-3)	<0.001
Fish	3 (1-3)	3 (1-3)	0.136
Seafood (other than fish)	1 (0-3)	1 (1-3)	<0.001
Dairy products	3 (1-7)	5 (3-7)	0.009
Multivitamin	0 (0-7)	7 (1-7)	<0.001

IQR = interquartile range.
[a]The data of pregnant women had been published previously.[11]

Table 5

Multivariate analysis of the risk factors for UIC < 100 μg/L

Variables	Adjusted OR (95% CI)	*P*
Age (20-29 vs ≥30 y)	3.38 (1.49-7.65)	0.004
Postpartum nourishment diet noneater (ref.: eater)	1.98 (0.93-4.19)	0.076
Multivitamin nonuser (ref.: user)	1.89 (1.03-3.48)	0.041
Infant diet composition (ref.: <50% breast milk)		
50% breast milk	1.56 (0.73-3.37)	0.253
>50% breast milk	2.93 (1.37-6.25)	0.005

OR = odds ratio; UIC = urinary iodine concentration.

Although the median UIC is the currently proposed criterion for assessing iodine nutrition in lactating women, there is limited scientific evidence to support this recommendation.[15] A study of exclusively breastfeeding women showed that populations with the same median UIC (33 μg/L) had markedly different breast median iodine concentrations (BMICs) of 124 and 30 μg/kg.[14] Based on a suggested daily iodine requirement of 72 μg for infants aged 2 to 5 months, the BMIC of 124 μg/kg covered the daily infant requirement, whereas the BMIC of 30 μg/kg was far from sufficient.[16] In this study, the median UIC in mothers of infants who received more breast milk than formula milk was 86.1 μg/L. This value was lower than the threshold of 100 μg/L. Nevertheless, it did not necessarily indicate iodine deficiency because preferential partitioning of iodine into breast milk occurs when iodine intakes are at the lower limit of adequacy.[14]

Owing to the fetal and infant dependency on maternal supply of iodine, the demand for iodine is higher during pregnancy and lactation.[6] To ensure iodine sufficiency during this period, routine iodine supplementation has been suggested in some countries, such as the United States and Canada.[17] In the present study, the median UIC in women who did not ingest multivitamins was 102.6 μg/L, which was marginally over the lower limit for iodine sufficiency. In our previous study of pregnant women in TVGH, multivitamin intake was very popular (79.4% of women).[11] The percentage of women taking supplementation was decreased to 49.0% during lactation and this was significantly associated with a lower UIC in both bivariate and multivariate analyses. The underlying reason for this change is unclear. Nevertheless, we postulate that lack of knowledge on supplementation during lactation and the traditional Chinese culture of receiving postpartum care and a postpartum nourishment diet may play a role.

For women living in postpartum care centers, a specific postpartum nourishment diet is provided by a specialized dietician. Women tend to believe that these diets are well designed and

provide adequate amounts of all kinds of nutrients. Therefore, a belief that there is a decreased need for dietary supplementation is common. Although the macronutrient contents of these diets are recorded, the micronutrient contents are often overlooked. This is evidenced by the decreasing intake of various iodine-containing foods from pregnancy to postpartum (Table 4). Fluids constitute a large part of breast milk; in Chinese culture, it is customary to provide substantial amounts of soups and teas to lactating mothers to enhance the production of breast milk. In a recent survey, the median iodine concentration in 30 types of herbal cuisine soup and teas used in postpartum diet was 23.1 (IQR: 6.7-36.7) μg/L and <10 μg/L, respectively.[18] In the present study, intake of a postpartum nourishment diet was not significantly associated with UIC after adjustment for other variables and did not appear to be a major determinant of iodine sufficiency. Other factors, such as multivitamin intake and age, may be more important.

Compared with the general population in Taiwan, the age of delivery in this study was older (island-wide statistics in Taiwan vs present study, mean age: 32.1 vs 33.6 years; age ≥ 35 years: 25.5% vs 40.4%; age 30-34 years: 36.0% vs 42.4%; and age 20-29 years: 31.8% vs 17.8%, respectively) and the educational status of the studied women was higher (Taiwan vs present study, university or above: 58.1% vs 95.4%, respectively).[19] In this study, 5.9% and 23.8% of women had a master's degree or above in the age groups 20 to 29 and 30 to 34 years, respectively (p = 0.019). This suggests that the educational status and age at the time of delivery are highly correlated, and those who receive higher education tend to deliver babies later in life. A postpartum nourishment diet and fish were consumed less frequently by women in the younger age groups (Table 3). These items are more affordable to those with a higher socioeconomic status; in Taiwan, this is usually the group of individuals aged >30 years.[20] In this study, the median UIC in the younger age group (20-29 years) was 74.4 μg/L, and younger age was associated with a 3.38-fold increase in the likelihood of having a UIC <100 μg/L. This suggests that the UIC condition outside of the Taipei metropolitan area can be completely different, with values far lower than those recorded in the present study. This is particularly relevant to women who terminated their education earlier in life, became pregnant at younger ages, and were less wealthy. A national survey is warranted to determine the overall iodine nutritional status of lactating women in Taiwan.

Several limitations of this study should be noted. First, the findings of this study only represent the condition in the Taipei metropolitan area. Second, the FFQ is qualitative and we do not have quantitative information on the portions/servings of food to calculate the actual amount of iodine intake. A national survey with more detailed information on food servings/size is needed to determine the actual dietary iodine sources. In addition, our analysis may be biased due to the high variation in UIC in certain subgroups with fewer case numbers. Finally, in the absence of data on BMIC, the maternal iodine status may be underestimated.[21]

In conclusion, the results of the present study suggest that the iodine nutritional status of lactating women in northern Taiwan is generally adequate. However, women of younger age and those who do not take multivitamins may continue to be at increased risk of iodine deficiency.

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