

Iodine nutritional status and awareness of iodine deficiency among adults, including pregnant women, in Tuguegarao, Philippines

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Objectives: Iodine deficiency causes multiple health problems. Previously we reported that 96% of high school students in Tuguegarao, Philippines had adequate iodine levels. However, iodine deficiency-associated problems remain among adults in the Philippines. Therefore, we evaluated iodine nutritional status and goiter prevalence among adults, including pregnant women, in Tuguegarao, Philippines.

Methods: A total of 245 adults, including 31 pregnant women, provided samples for urinary iodine analysis, and all pregnant women completed a questionnaire about iodine deficiency.

Results: The median urinary iodine level was $164.0 \pm 138.4 \mu\text{g/L}$; 38.4% of the participants were iodine deficient, according to the International Council for Control of Iodine Deficiency Disorders (ICCIDD) criteria. No severe iodine deficiency was observed. Among the 31 pregnant women, 24 (77.5%) fell into the iodine deficient category defined by a stricter World Health Organization (WHO) guideline, in which iodine deficiency is considered when urinary iodine levels are below $150 \mu\text{g/L}$. Almost half (42%) of the pregnant women were unaware of the harmful effects of iodine deficiency on the human body and their fetus.

Conclusions: Although iodine nutritional status in the Philippines has improved, iodine deficiency still exists among adults, especially among pregnant women. Therefore, our study strongly suggests that a better strategy should be established to monitor iodine nutritional status among adults continually, and to focus on populations susceptible to iodine deficiency, including pregnant women and women of reproductive age, to achieve the total elimination of iodine deficiency.

Key Words: Adults, Awareness, Iodine deficiency, Pregnant women

Iodine deficiency is one of the most common nutritional problems, from which approximately one billion people worldwide suffer. Since the United Nations summit conference in 1990 re-

solved to eradicate iodine deficiency, efforts to increase public awareness and preventive education have actively been practiced around the world. As a result, the number of countries where

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teenage students suffer from iodine deficiency decreased from 130 (out of 191) in 1999 to 54 in 2003 and 32 in 2011, according to reports from the World Health Organization (WHO) and the International Council for Control of Iodine Deficiency Disorders (ICCIDD). In 2013, iodine deficiency was found in only 30 countries; the degree of deficiency was moderate in 9 countries and mild in the remaining 21 countries, and no instances of severe iodine deficiency were reported.¹

In 1995, the Philippines passed the Act for Salt Iodization Nationwide (ASIN) law, which imposed the use of iodized salt by including 20 – 40 μg of iodine per 1 g of salt in order to eliminate iodine deficiency.² The Philippines' national nutrition study in 2003 indicated that children between the ages of 6 and 12 had an average urinary iodine concentration (UIC) level of 142 $\mu\text{g/L}$ and 11.4% of children had a severe iodine deficiency ($< 50 \mu\text{g/L}$). In 2008, another nutrition study reported that children between the ages of 6 and 12 had an average UIC level of 132 $\mu\text{g/L}$.³ Despite the intervention efforts, iodine deficiency still exists, particularly among infants, and endemic goiters due to iodine deficiency are common in this country.

Iodine is not only essential for synthesizing thyroid hormones, but also crucial in developing an embryo's brain.⁴ However, many mothers are iodine deficient and approximately 380 million infants per year in developing countries are in danger of chronic brain damage due to an iodine

deficiency.^{5,6} The Philippines' national nutrition study reported that the UIC among pregnant women was 111 $\mu\text{g/L}$ in 2003 and 105 $\mu\text{g/L}$ in 2008,³ which would be within the optimal iodine range if these women were not pregnant. However, the WHO advocated for a stricter guideline for iodine deficiency during pregnancy, recommending an iodine intake of 250 μg daily and defining iodine deficiency as UIC less than 150 $\mu\text{g/L}$.⁷ It is notable that, in the Philippines, the UIC for breast-feeding mothers was very low at 81 $\mu\text{g/L}$.³ Iodine deficiency affecting infants is not only a problem in developing countries, but even in the United Kingdom iodine deficiency exists; British infants whose mothers consumed less than 150 μg of iodine per day in the early stages of pregnancy had lower speaking and reading intelligence at the age of 8 or 9 compared with British infants whose mothers consumed more than 150 μg of iodine per day.⁸ Iodine deficiency exists among pregnant women even in Korea, an area known for excessive iodine.⁹ Therefore, we must focus on the most vulnerable populations, such as pregnant women, to eliminate iodine deficiency.

We have previously reported that 96% of high school students in Tuguegarao, Philippines received adequate iodine, but without appreciating that iodine intake is important for brain development during pregnancy.¹⁰ In this study, we assessed the iodine nutritional status and awareness of iodine deficiency in an adult population, including pregnant women, in the same area of the

country to provide fundamental data that can be used to establish a better strategy to eradicate iodine deficiency in the future.

MATERIALS AND METHODS

Study population

This study was conducted with adults who were 18 years old or older residing in Tuguegarao, Cagayan Valley, Philippines in January 2015. A total of 268 participants provided samples for urinary iodine analysis, among whom 49 (18.2%) were males and 219 (81.8%) were females, including 31 pregnant women. Height (in cm) and weight (in kg) were measured for all participants and was used to calculate the body mass index (BMI). All pregnant women answered a questionnaire about their awareness of iodine deficiency.

This study was approved by the Institutional Review Board (IRB) of Cagayan State University Hospital and Kosin University Gospel Hospital. Informed consent was obtained from all participants.

Measurement of urinary iodine concentrations

Midstream voided urine samples (approximately 20 ml) were collected from 245 participants in wide-mouthed screw capped plastic bottles. The samples were immediately refrigerated until analysis. Urinary iodine concentrations (UIC) were determined by a modified microplate method employing ammonium persulfate digestion

followed by the Sandell-Kolthoff Reaction,¹¹ which is one of the three most common methods used by participants of Ensuring the Quality of Iodine Procedures (EQUIP) of the US Centers for Disease Control and Prevention (CDC).¹² Briefly, all urine samples and standards (0, 20, 40, 80, 120, 200, 300 g/L KIO₃) were allowed to reach ambient temperature, then 250 µl of each sample and standard were mixed with 1 ml of ammonium persulfate solution. The mixtures were incubated on a heating block for 60 min at 95 °C and cooled to room temperature. After transferring 50 µl of each mixture to a 96 well plate in duplicate, 100 µl of arsenious acid solution and 50 µl ceric ammonium sulfate solution were added sequentially and incubated for 30 seconds and 30 min, respectively. After reading the absorbance at 405 nm, UIC was determined using standard curves constructed for each plate. The iodine deficiency grade was defined according to the WHO's median UIC criteria as follows: < 20 µg/L, severe iodine deficiency; 20 – 49 µg/L, moderate iodine deficiency; 50 – 99 µg/L, mild iodine deficiency; 100 – 199 µg/L, optimal; 200 – 299 µg/L, more than adequate; and > 300 µg/L, excessive.¹³ As stated above, the WHO recommends a stricter guideline for iodine deficiency during pregnancy, defining iodine deficiency when the UIC is less than 150 µg/L.⁷ Table 1 shows the two definitions of iodine nutritional status.

Questionnaires

The questionnaires consisted of eight main

Table 1. Definition of iodine nutritional status

Median ($\mu\text{g/L}$)	UIC*	Iodine nutritional status for general population	Median ($\mu\text{g/L}$)	UIC*	Iodine nutritional status for general population
< 20		Severe iodine deficiency	< 150		Insufficient
20 – 49		Moderate iodine deficiency	150 – 249		Adequate
50 – 99		Mild iodine deficiency	250 – 499		More than adequate
100 – 199		Optimal	≥ 500		Excessive
200 – 299		More than adequate			
≥ 300		Excessive			

*UIC, urinary iodine concentration

questions and one subquestion: 1) Have you ever heard of the effects of iodine deficiency on the human body? 2) Can you list some problems (disorders) that are the result of iodine deficiency? Which problems (disorders)? 3) Where do you receive information about iodine deficiency disorders and preventing them? 4) What do you need to improve iodine deficiency? 5) Have you ever heard of iodized salt? 6) Do you buy iodized salt? 6-1) If you answered 'No,' why don't you buy iodized salt? 7) Do you know the advantages of iodized salt over regular salt? 8) What are these advantages?

Statistical analysis

All values were presented as the mean \pm standard deviation unless otherwise stated. Differences among groups were analyzed by ANOVAs using the Statistical Package for Social Sciences program (SPSS, version 22.0, Chicago, IL, USA). P-values less than 0.05 were considered statistically

significant.

RESULTS

Clinical characteristics of study participants

Clinical features of participants, including age, height, weight, BMI and median UIC were presented in Table 2. The average age was 50.29 ± 18.1 (range, 20 – 91) for male participants, 44.8 ± 16.4 (range, 18 – 89) for female participants and 25.9 ± 7.3 (range, 17 – 44) for pregnant women. Men were noticeably taller and heavier than were the women, but the pregnant women's body weight and BMI were greater than those of the men. Although women had a median UIC value of $180.8 \pm 147.3 \mu\text{g/L}$, which appeared to be higher than the men's UIC, $152.7 \pm 174.5 \mu\text{g/L}$, pregnant women's median UIC value was the lowest level, at $119.4 \pm 94.9 \mu\text{g/L}$.

Table 2. Clinical characteristics and UIC of men, women and pregnant women

	Men	Women	Pregnant women	<i>P</i> -value*
Number	49	188	31	
Age (years)	50.29 ± 17.9	44.8 ± 16.4	25.9 ± 7.3	< 0.01
Height (cm)	164.5 ± 12.8	153.8 ± 6.1	155.8 ± 4.0	0.12
Body weight (kg)	57.9 ± 13.7	51.2 ± 10.6	57.0 ± 6.5	0.01
BMI (kg/m ²)	21.3 ± 3.9	21.6 ± 3.8	23.4 ± 2.8	0.02
Median UIC (μg/L)	152.7 ± 174.5	180.8 ± 147.3	119.4 ± 94.9	0.02

**P*-values reflect comparison between women and pregnant women.

Iodine nutrition status of adults and pregnant women

Eighty-one participants out of total 237 (33.9%) had an iodine deficiency (median UIC < 100 μg/L).

Thirteen participants (5.0%) had a moderate iodine deficiency and 68 (28.9%) had a mild iodine deficiency; none had severe iodine deficiency (Fig. 1). Although a large portion of the study par-

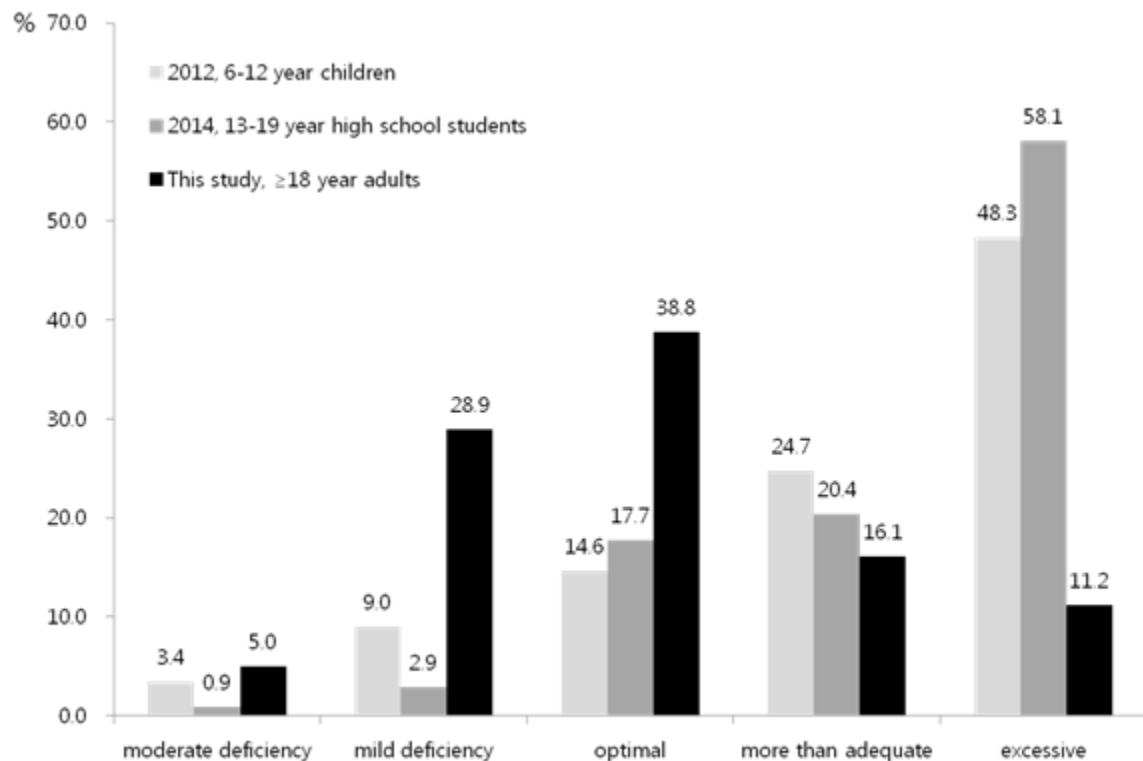


Fig. 1. Iodine nutritional status of adults compared with previous surveys in same area, Tuguegarao, Philippines

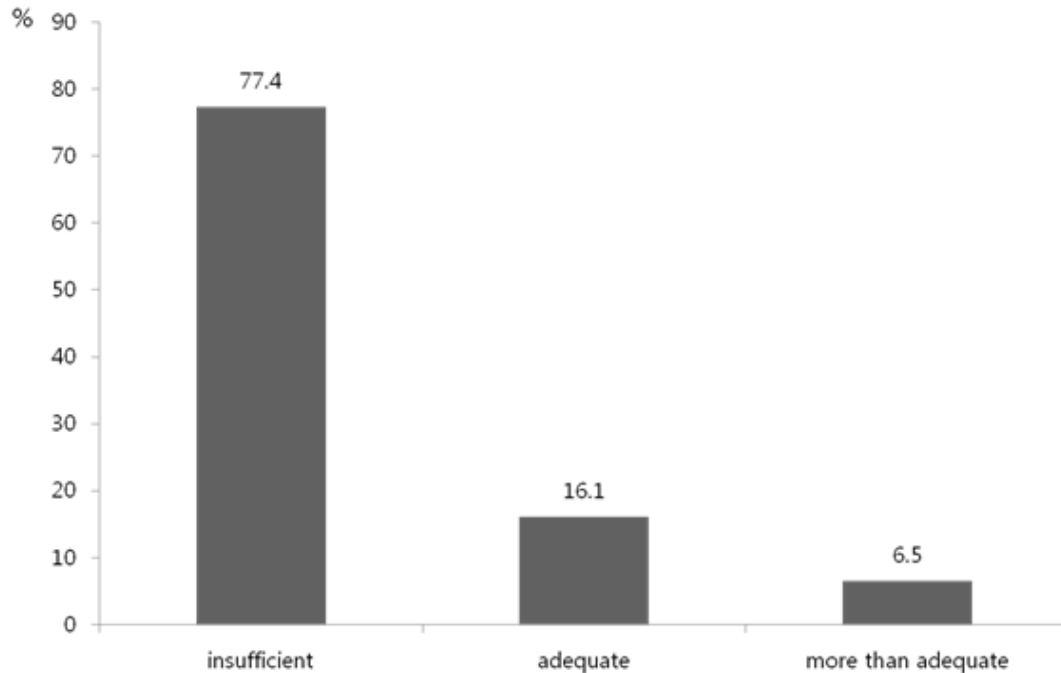


Fig. 2. Iodine nutritional status of pregnant women in Tuguegarao, Philippines

ticipants (38.8%) exhibited optimal or above optimal UIC, the percentage was much lower than our previous study, which found that 96.2% of high school students in the same area had an adequate iodine nutrition status.¹⁰

In the current study, 31 pregnant women were included, and 24 pregnant women (77.4%) fell into an iodine deficient status following the stricter guideline (Fig. 2).

Awareness of iodine deficiency in pregnant women

The results for the questionnaires are shown in Table 3. For the first question, 67.7% of the pregnant women answered that they have heard about the problems associated with iodine deficiency. Although they could list some problems (disorders) resulting from iodine deficiency, most

participants (54.8%) could only identify goiters as a problem associated with iodine deficiency. Only 35.5% of the pregnant women know about the effects of iodine deficiency on their fetus. The main sources from which pregnant women received information about iodine deficiency disorders were medical workers (64.5%), followed by school (45.2%). In response to the question on how to improve iodine deficiency, 54.8% of participants replied that they need to consume seafood; only 41.9% answered that they need to consume iodized salt. Pregnant women predominantly reported (80.6%) that they use iodized salt. Every woman who answered they did not use iodized salt chose the reason 'I don't know why it is necessary.' Almost every pregnant woman (87.1%) reported that they are familiar with the advantages of iodized salt, but only 54.8% were able

Table 3. Awareness of iodine deficiency among pregnant women

Question	Answer	% (n)
1) Have you ever heard of the effects of iodine deficiency on the human body?	Yes No	67.7 (21) 32.3 (10)
2) Can you list some problems (disorders) that are the result of iodine deficiency? Which problems (disorders)?	Miscarriage/stillbirth Heart pain Retarded development of children Reduced immunity Memory loss Goiters	35.5 (11) 41.9 (13) 35.5 (11) 45.2 (14) 35.5 (11) 54.8 (17)
3) Where do you receive information about iodine deficiency disorders and preventing them?	Printed material Television, radio Medical worker Member of your family School	29.0 (9) 38.7 (12) 64.5 (20) 38.7 (12) 45.2 (14)
4) What do you need to improve iodine deficiency?	Play sports Improve the environment Consume seafood More and more complete rest Consume iodized salt Consume vitamins Consume dairy products	25.8 (8) 38.7 (12) 54.8 (17) 48.4 (15) 41.9 (13) 64.5 (20) 58.1 (18)
5) Have you ever heard of iodized salt?	Yes No	87.1 (27) 12.9 (4)
6) Do you buy iodized salt?	Yes No	80.6 (25) 19.4 (6)
6-1) If you answered 'No', why don't you buy iodized salt?	I don't know why it is necessary It is usually more expensive No one advise me to (or I don't want it) Other	(6) (2) (1) (3)
7) Do you know the advantages of iodized salt over regular salt?	Yes No	87.1 (27) 12.9 (4)
8) What advantages are there?	Better taste Better digestion Reduces iodine deficiency in the human body Other	45.2 (12) 32.3 (10) 54.8 (17) 19.4 (6)

to pinpoint the improvement of iodine deficiency as one of the advantages.

DISCUSSION

Iodine is an essential micronutrient; it is necessary in the development of thyroid hormones.

Therefore, maintenance of adequate iodine levels is essential to avoid thyroid diseases. On average, 14 mg of iodine is present in the human body and 75% of this is located in the thyroid.¹⁴ Homeostasis of the thyroid hormones in blood is sustained by secretion of thyroid stimulating hormones (TSH) from the pituitary gland, and the thyroid, stimulated by TSH, uses iodine to produce and secrete thyroid hormones. Therefore, if iodine intake is insufficient, iodine deficiency occurs. Iodine deficiency causes numerous developing and organic dysfunctions depending on the age of an individual. When iodine deficiency is severe, endemic goiters, cretinism, and perinatal and neonatal mortality increase.¹⁵ Traditionally, endemic goiter was suspected when a significant percentage of residents in a certain area have enlarged thyroids; usually when more than 5% of children between the ages of 6 and 12 have a goiter. A major cause of goiters is iodine deficiency. According to UNICEF and ICCIDD, until 1990, 1.57 billion members of the world population were in danger of iodine deficiency, 650 million had endemic goiters and 10 million suffered cretinism.¹⁶ In 1993, when goiter prevalence was surveyed in Asian countries, the rate was 44% in Nepal, 28% in Indonesia and 11% in Bangladesh. Also, according to data in 1999, 12% of the 1.72 billion people in Southeast Asia had goiters and 41% were susceptible to goiters.¹⁷

The Philippines is classified an Asian country where only 36-69% of its areas are supplied with enough ionized salt based on the ICCIDD

categories. The Philippines is composed of 16 regions and 79 provinces. According to a national survey targeting 383,000 residents from 6 regions of the Philippines in 1983, the overall prevalence rate of iodine deficiency was only 12%.¹⁸ However, the prevalence rate in each province within these 6 regions varied greatly, with prevalence rates of iodine deficiency greater than 20% in 9 provinces. The area of interest in the current study, the Cagayan Valley, is located at northeastern side of the largest island in the Philippines, Luzon, which is 700 km away from Manila, the capital city of the country. This region has poor transportations and is isolated, since it is surrounded by mountains and rivers. According to a 1990 study, the prevalence rate of iodine deficiency in region II, which includes Cagayan, was 20-38% for Ifugao and 40% for Kal-Apayo.^{19,20}

Our current study revealed that the median UIC of adult Cagayan residents was 180.8 $\mu\text{g/L}$ for women and 152.75 $\mu\text{g/L}$ for men. However, 33.9% of the participants are still iodine deficient, indicating that the iodine nutritional status in this region needs to be improved. Our previous study on high school students showed that the median UIC was 355.3 $\mu\text{g/L}$ and only 3.8% of students were considered iodine deficient.¹⁰ In the Philippines, it appears that iodine deficiency is almost overcome among school-aged children and adolescents;^{10,20} however, as it showed at Fig. 1 it still remains an important public health problem among adults. The improvement of iodine nutrition status in younger populations may be the result of food

prepared at schools, which use iodized salt.

The most serious problem is the high frequency of pregnant women with iodine deficiency. In the current study, 31 pregnant women were included, of whom 24 (77.5%) had iodine deficiency; 19 pregnant women (61.3%) had a UIC lower than 100 $\mu\text{g/L}$. The median UIC level of pregnant women was only 119.4 $\mu\text{g/L}$. This result is very similar with the Philippines' national nutrition survey, which reported that, among pregnant women, the average UIC was 111 $\mu\text{g/L}$ in 2003 and 105 $\mu\text{g/L}$ in 2008.³ This indicates that there has been no improvement in iodine deficiency among pregnant women at least in the Cagayan area for the period longer than 10 years.

During pregnancy, the body's demand for iodine increases, and iodine becomes even more important.²¹ Therefore, a stricter definition of iodine deficiency, urinary iodine level less than 150 $\mu\text{g/L}$, as per the WHO guidelines, should be applied for pregnant women. Although the mechanisms for how iodine deficiency influences the stages of pregnancy is not fully understood, severe iodine deficiency during pregnancy can cause goiter, miscarriage, and increase in neonatal mortality and cretinism. In our study, two-third of pregnant women did not acknowledge these as iodine deficiency-associated problems. Although the positive response on buying iodized salt was approximately 80%, the portion of deficient subjects was 77.5% among pregnant women. It is probably due to the absolute poverty of this area. We suspect other nutrients also deficient.

The WHO and ICCIDD have specified criteria for iodine deficiency and fostered preventive education and treatment, initially targeting school-aged children. As a result, rates of iodine deficiency have substantially decreased worldwide. Currently, interest in iodine deficiency among women has increased, particularly as iodine deficiencies among pregnant women in many European countries have been reported.²²⁻²⁶ Iodine monitoring programs for pregnant women have been implemented in 15 provinces of Thailand since 2000.²⁷ The most effective method to prevent and improve iodine deficiency is iodized salt,²⁸ even among pregnant women.²⁹ However, the current study found that half of the pregnant women were unaware of why they should consume iodized salt. Considering these results, more effort is needed in the Philippines to prevent iodine deficiency among adults in general, and particularly among pregnant women. An educational program about the effects of iodine deficiency on the fetus and infant, and about the importance of iodized salt should be provided through schools, medical centers and public health institutes.

In conclusion, our studies, previously covering from elementary school students to middle and high school students, and now further to adult populations revealed that iodine deficiency is still present among adults and pregnant women in Tuguegarao, Cagayan Valley, Philippines. More importantly, 77.5% of pregnant women had an iodine deficiency. Although the sample size for pregnant women was small at 31, the significantly high

rate of iodine deficiency together with poor understanding of the importance of iodine supplementation clearly suggest that this group should be the center of attention for immediate improvement of iodine nutrition status. A better strategy and educational program should be devised that focuses on populations susceptible to iodine deficiency, including pregnant women and women of reproductive age, to achieve the total elimination of iodine deficiency.

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