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Iodine Status in Pregnant Women, Lactating Mothers, and Newborns in an Area with More Than Two Decades of Successful Iodine Nutrition

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Abstract Pregnant women, lactating mothers, and their newborns constitute the target population for prevention and control of iodine deficiency. Hence, the aim of this study was to evaluate the iodine nutrition status among these vulnerable groups in an area with more than two decades of successful elimination of iodine deficiency. In this cross-sectional study conducted in health care centers of Tehran, 100 pregnant women and 84 lactating mothers and their newborn were randomly selected. Urinary iodine concentration and iodine content of salts were measured using the Sandell-Kolthoff and titration methods, respectively. Urinary iodine concentration <150 μg/L for pregnant women and <100 μg/L for lactating mothers and newborns was considered as iodine nutrition inadequacy, respectively. Median (interquartile range [IQR]) urinary iodine concentration (UIC) was 103 (59–155) μg/L in pregnant women, 77 (42–194) μg/L in lactating mothers, and 198 (84–260) μg/L in newborns. Median (IQR) iodine content of salt was 26 (21–30) ppm and 25 (18–28) ppm in pregnant women and lactating mothers, respectively ($P = 0.462$). Iodine content of salt was significantly correlated with UIC of pregnant women ($r = 0.24$, $P = 0.019$), but no correlation was found among lactating mothers ($r = 0.12$, $P = 0.316$). Neonatal UIC was significantly correlated with iodine content of salt consumed by their mothers ($r = 0.49$, $P = 0.001$). Despite suboptimal iodine status among subgroups of Tehranian pregnant and lactating women, iodine nutrition status of newborns was within optimal levels, which may be explained by a compensatory mechanism in the mammary glands.

Keywords Iodine nutrition · Pregnant women · Lactating mothers · Newborns

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Introduction

Iodine is an essential trace element for thyroid hormone synthesis, which plays a critical role in normal growth, mental and neurological development, reproduction, and survival. Pregnant women, lactating mothers, and infants constitute the target population for prevention and control of iodine deficiency

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mainly due to its detrimental effects occurring during fetal and early postnatal life [1–3].

Based on the World Health Organization (WHO), the ICCIDD, and the United Nations Children's Fund (UNICEF) recommendations, in countries with effective and sustained salt iodization, pregnant and lactating women have no need for iodine supplements [4]; however, the American Thyroid Association (ATA) [5] and the Endocrine Society [6] recommend that pregnant and lactating women take 150 μg supplements of iodine daily, a recommendation based on the most recent data from the NHANES survey (2005–2010), which indicated that urinary iodine concentration (UIC) levels <100 and <150 μg/L were observed in more than one third and a half of American women of childbearing age and pregnant mothers, respectively [7].

The Islamic Republic of Iran has been recognized and declared a country free of iodine deficiency disorders (IDD) in 2000, following implementation of universal salt iodization with 20–40 ppm and sustained monitoring of the IDD program [8]. However, previous studies have shown an increase percentage of UIC <100 μg/L among Tehranian childbearing age women [9, 10]. Mirmiran et al. has shown that median 24-h UIC among women of childbearing age was 83 μg/L and 59 % of them had inadequate iodine status [11]. Furthermore, a few studies have reported the risk of iodine deficiency among pregnant and lactating women and breast-fed infants in Iran [12–14]. For instance, in a recent study by Amouzegar et al., which conducted among 203 pregnant women from November 2004 to November 2006 indicating UIC <150 μg/L in 24, 45, and 52 % of pregnant women in the three trimesters of pregnancy, respectively [13].

Hence, considering evidence of iodine inadequacy among women of childbearing age in Tehran and the limited data available on the iodine status of pregnant and lactating women and infants in recent years, this study was conducted to evaluate iodine status among selected vulnerable groups in Tehran, an area with over two decades of successful iodine nutrition.

Materials and Methods

Subjects

In this cross-sectional study conducted in the southern region of Tehran, from a list of all health care centers, four health care centers were randomly selected. Among pregnant women who were referred to routine prenatal care units of health care center and had medical health record, 100 pregnant women were randomly selected and asked to participate in the current study. In addition, 100 lactating mothers and their newborns, aged between 3–5 days postpartum, from health care centers responsible for newborn screenings were recruited of whom 16 mothers and newborns declined to participate. Pregnant women, lactating mothers, and their newborns were included in the current study if they met the following criteria: healthy pregnant and lactating women with no history of thyroid disorders, not currently using iodine-containing disinfectants, i.e. povidone iodine, have a singleton birth, and exclusively breast feed; infants born full-term (gestational age, 37–42 weeks) with normal birth weight (2500–4200 g) and who had a normal serum TSH during neonatal screening. Using an interviewer-administrated questionnaire, maternal information on age, education, occupation, last pregnancy, gravidity, parity, history of abortion in previous pregnancies, use of iodine-containing supplements during pregnancy, and the type of delivery (in lactating mothers) were documented and newborn demographic information including, birth date, sex, and birth weight, height, and head measurements was obtained. Written informed consent was obtained after the study protocol and objectives were fully explained to all women and/or their husbands. The present study was approved by the ethics committee of the Research Institute for Endocrine Sciences, Shahid Beheshti University of Medical Sciences.

Urine Collection

At the first visit, labeled plastic bottles and adhesive pediatric urine bags (SUPA medical services, Tehran, Iran) were used to collect urine samples of pregnant and lactating women and newborns according to the detailed instructions provided. If mothers were not able to collect urine sample after three attempts, they were asked to collect urine sample of newborns by holding a specimen bottle in the urine stream. All samples were collected and sent to the iodine laboratory of the Research Institute for Endocrine Sciences, where they were transferred into screw-top labeled plastic vials. The aliquots were kept frozen at −20 °C until iodine concentrations were measured.

Salt Sample Collection

Two tablespoon salt samples used during cooking and/or as table salt were collected from each of the mothers at the same time as urine collection. Some mothers used two types of salt, in which case, samples of both were collected. The samples were kept in lightproof, closed plastic cans and labeled with the code allocated to each mother.

Laboratory Measurements

Iodine concentration of salt samples was determined using the iodometric titration method with 1 ppm sensitivity and 1 % coefficient of variation [15]. The values obtained were shown in parts per million. Iodine concentrations in urine sample were analyzed using the Sandell-Kolthoff (acid-digestion) reaction [16] and results are expressed as micrograms of iodine per liter of urine. Intra-assay coefficients of variation at UIC values of 8.5, 17.5, and 36.0 μg/L were 8.5, 6.2, and 8.0 %, respectively. The inter-assay coefficients of variation at concentrations of 8.5, 17.4, and 36.4 μg/L were 10.3, 9.7, and 8.0 %, respectively.

Definition of Terms

According to WHO/ICCIDD/UNICEF criteria, median UIC <150 and ≥150 μg/L for pregnant women and median UIC <100 and ≥100 μg/L for lactating mothers and infants were considered as iodine nutrition inadequacy and adequacy, respectively [17].

Statistics Analysis

Frequency distribution (percentage), mean ± SD, and median (interquartile range [IQR]) were expressed according to categorical and continuous variables. Normality of the variables was assessed by the Kolmogorov-Smirnov test and histogram chart. Chi-square and Mann-Whitney or *t* tests were used to assess significance of differences for categorical and continuous variables in basic characteristics of pregnant and lactating women. Correlations between maternal and neonatal UIC and iodine content of salt were assessed using Spearman correlation coefficient. Statistical analyses were done using IBM SPSS for windows (version 20.0, 2011, IBM Corp., Armonk, NY), $P < 0.05$ being considered significant.

Results

A total of 100 pregnant women, 84 lactating mothers and 84 newborns, aged 27.2 ± 5.6 years, 28.2 ± 5.6 years, and 4.2 ± 0.7 days, respectively, participated in this study. Mean ± SD gestational age of pregnant women was 12.5 ± 2.7 weeks. Table 1 shows basic characteristics of pregnant and lactating women. There was no significant difference in use of iodine-containing supplements between the two groups. Mean ± SD birth weight, height, and head circumference among newborns was 3220 ± 345 g, 50.0 ± 1.6 cm, and 34.6 ± 1.4 cm, respectively.

Data on UIC levels in pregnant women, lactating mothers and their newborns are presented in Table 2. Mean ± SD and median (IQR) UIC were 119 ± 75 and 103 (59–155) μg/L in pregnant women, 120 ± 97 and 77 (42–194) μg/L in lactating mothers, and 180 ± 99 and 198 (84–260) μg/L in their newborns, respectively. There were no differences in UIC between male and female newborns or between pregnant and lactating women of varying gravidity and parity. No significant difference was observed in the UICs of newborns, whose mothers had varying gravidity and parity. Also, there was no significant difference in maternal and neonatal UICs of mothers who delivered naturally or by cesarean section. The proportions of UIC <100, 100–150, and >150 μg/L are shown in Fig. 1. Frequency distribution of UIC <150 vs. ≥150 μg/L (a cutoff point for iodine sufficiency during pregnancy) was 72 vs. 28 % in pregnant women. Frequency distributions of UIC <100 vs. ≥100 μg/L (a cutoff point for iodine sufficiency during lactation and infancy periods) were 59 vs. 41 % in lactating mothers and 34 vs. 66 % in newborns, respectively.

In salt samples collected from each mother, mean ± SD and median (IQR) iodine content of salt were 23 ± 11 and 26 (21–30) ppm in pregnant women and were 22 ± 11 and 25 (18–28) ppm in lactating mothers, respectively. There was no significant difference in iodine content of salt between the two groups. Iodine content of salt was significantly correlated with UIC of pregnant women ($r = 0.24$, $P = 0.019$), whereas there was no significant correlation between iodine content of salt and of lactating mothers ($r = 0.12$, $P = 0.316$). However, neonatal UIC was significantly correlated with the iodine content of salt consumed by their mothers ($r = 0.49$, $P = 0.001$).

Discussion

The present cross-sectional study indicates that despite iodine sufficiency in the general Iranian population (assessed by the median UIC as the indicator in schoolchildren), subgroups of Tehranian pregnant and lactating women, but not their newborns, have inadequate iodine nutrition. This finding is in agreement with previous studies with larger sample size conducted in Tehran indicating that a salt iodization program with 20–40 ppm potassium iodide is not adequate for providing the iodine requirements of these vulnerable groups, particularly for pregnant women and lactating mothers [12–14].

According to criteria of the WHO/ICCIDD/UNICEF, UIC is a cost-efficient and easily obtainable indicator for iodine status in epidemiological studies [17]. Since the majority of iodine absorbed by the body is excreted in the urine, it is considered a sensitive marker of current iodine intake and can reflect recent changes in iodine status; however, it should not be applied to individuals because of significant day-to-day variation in salt intake [18], the main source of dietary iodine in many countries. Moreover, although median UIC in a representative sample of schoolchildren provides an adequate assessment of a population's iodine nutrition, it may not be an acceptable indicator for iodine status in pregnant and lactating women [17]. Similar to our findings, several studies indicate that not only pregnant and lactating women in iodine-deficient regions but also those residing in iodine-sufficient areas may suffer from iodine deficiency [12–14, 19–25]. Moreover, as shown in our study, in different countries, iodization programs which were sufficient for their general population were found to be

Table 1 Basic characteristics of pregnant and lactating women in Tehran

Characteristics	Pregnant women, n = 100	Lactating mothers, n = 84
Age (year)	27.2 ± 5.6	28.2 ± 5.6
Education (year)	8.8 ± 3.7	11.0 ± 3.2
Occupation, n (%)		
Homemaker	100 (100.0)	78 (94.0)
Employee	0 (0.0)	5 (6.0)
Gravidity, n (%)		
Primigravidity	23 (23.0)	28 (33.7)
Multigravidity	87 (87.0)	55 (66.3)
Parity, n (%)		
Primiparity	48 (48.0)	37 (44.6)
Multiparity	26 (26.0)	46 (55.4)
History of abortion, n (%)		
Yes	15 (15.0)	18 (21.7)
No	85 (85.0)	65 (78.3)
Use of iodine-containing supplements, n (%)		
Yes	5 (5.0)	5 (6.0)
No	75 (75.0)	62 (74.7)
Do not know	20 (20.0)	15 (19.3)
Delivery type, n (%)		
NVD	–	26 (31.3)
CS	–	57 (68.7)

NVD natural vaginal delivery, *SC* cesarean section

insufficient for pregnant and lactating women [14, 20, 22]. For instance, in Australia and New Zealand, where studies had indicated iodine deficiency in their population, the iodine status was inadequate in pregnant and breastfeeding women, especially in those not consuming iodine-containing supplements [20, 24, 26, 27]. In addition, it has been shown that with median UIC 129 μg/L more than half of American pregnant women have inadequate iodine status [7, 28] and lactating mothers in Switzerland suffer from iodine deficiency [19].

In present study, we observed that median UIC in newborns was within optimal levels despite suboptimal iodine status among their lactating mothers. We have previously shown that median UIC in Tehranian newborns was higher than in their mothers (271 vs. 107 μg/L) [29]. Our findings are also consistent with other studies in Ireland and Turkey [30, 31], indicating maternal UIC in breast-feeding mothers was significantly lower than their infants (76 vs. 100 μg/L) and (40 vs. 85 μg/L), respectively. It is noteworthy that in these studies, similar method was used for determination of iodine

Table 2 Urinary iodine concentration values in pregnant and lactating women and newborns

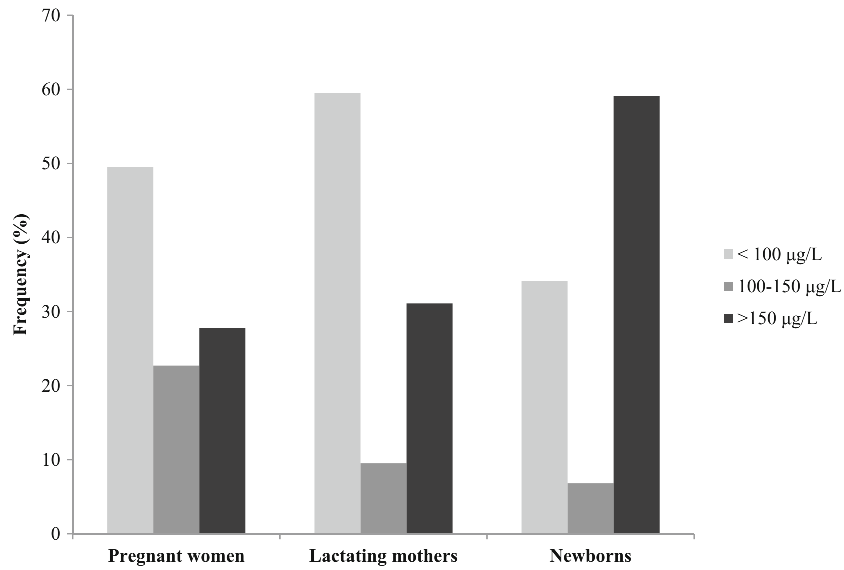
Values	Urinary iodine concentration (μg/L)		
	Pregnant women, n = 100	Lactating mothers, n = 84	Newborns, n = 84
Mean ± SD	119 ± 75	120 ± 97	180 ± 99
Median	103	77	198
Interquartile range	59–155	42–194	84–260
% UICs			
≥ 150[a]	28		
< 150	72		
≥ 100[b]		41	66
< 100		59	34

UIC urinary iodine concentration

[a] Based on cutoff point for iodine sufficiency during pregnancy

[b] Based on cutoff point for iodine sufficiency during lactation and infancy

Fig. 1 Frequency of urinary iodine concentrations in pregnant women, lactating mothers, and newborns



concentration in urine samples, however, the reason for this discrepancy apparently being attributed to the compensatory mechanism in the mammary gland with an upregulation of sodium iodide symporter, which is responsible for providing the nursing infant with iodine-enriched milk [32]. A similar pattern was found in the recent study from Turkey (84 vs. 279 μg/L); however, iodine deficiency in mothers and iodine excess in their newborns was attributed to the use of antiseptics containing iodine [33].

Currently, concerted efforts are being made in many countries to reduce salt intake for the prevention of cardiac diseases and hypertension, which can raise the concern that decreasing salt consumption will increase the risk of iodine deficiency [34]. On the other hand, as seen in most industrial countries, where consumption of iodized salt is limited, the increase in the urinary iodine concentration of the population may depend on the presence of iodine in foods, especially milk and dairy products [35]. Surveys conducted on individual consumption reveal that the frequency of milk consumption is associated in a dose-dependent manner with their urinary iodine concentrations [35] and those who do not consume dairy products may be at risk for iodine deficiency; a concern, in particular, has been raised about iodine status of pregnant and childbearing-aged women not consuming dairy products [36]. In Iran, where iodized salt is the main dietary iodine source, the amount of salt intake and its iodine content are two major determinants of iodine nutritional adequacy [10]. Although not documented, it has been seen that pregnant women advised to reduce salt intakes to prevent hypertensive disorders during pregnancy, in most cases, continue to do so until postpartum periods. Also, in agreement with our previous studies, we found that iodine content of salt in pregnant and lactating women was decreased to lower recommended limit of 20 ppm. It seems that both decrease of salt intake and iodine content of salt can be major contributors for inadequate iodine status in pregnant and lactating women in our study. Furthermore, in the current study, we found that only <10 % of pregnant and lactating women were taking supplements that contain iodine. As Iran is considered to be among countries with a longstanding, well-established universal salt iodization program, there is no emphasis on pregnant and lactating women using iodine-supplemented multivitamin and/or mineral tablets and no such guidelines have yet been documented by the medical community and public health authorities. However, based on the ATA and the Endocrine Society recommendations, for provision of adequate iodine nutrition among pregnant and lactating women, universal salt iodization should be implemented simultaneously with 150 μg iodine supplementation in daily prenatal vitamin/mineral supplements [5, 6].

The strength of this research is the assessment of iodine status, for the first time, among pregnant women, lactating mothers, and their infants simultaneously, which can give a reliable assessment of the current iodine status in these vulnerable groups after two decades of successful salt iodization. However, a single spot urine sample may be a poor indicator of habitual iodine intake because of variation in daily dietary iodine intake. We could not determine iodine nutrition status through iodine content of foodstuffs other than iodized salt, although in Iran, iodine sufficiency is totally dependent on the use of iodized salt and a significant portion of iodine intake comes from iodized salt, the main dietary iodine source which is used during cooking and as table salt. Also, caution is needed in interpreting these data due to the relatively small sample size of subgroups of the participants, which makes difficult generalization of these findings to Tehranian pregnant and lactating women.

In conclusion, despite suboptimal iodine status among selected Tehranian pregnant and lactating women, the iodine nutrition status of their newborns was within optimal levels. It seems that consumption of iodized salt with 20–40 ppm potassium iodide does not provide adequate iodine for pregnant and lactating women; however, compensatory mechanism in the mammary glands probably provides iodine-enriched milk to newborns.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no competing interests.

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