Urinary Iodine Concentrations in the High Background Radiation Areas of Kanyakumari District, Tamilnadu, India

Gopal Ganapathi M. BrahmaNandhan1,2,3, Naomi HayashiDa1, Yasuyuki Taira1, Jeyapandian Malathi3, David Khnna3, SubramanIyan Selvasekarapandian3, Naoki Matsuda2 and Noboru Takamura1

1) Department of Radiation Epidemiology, Nagasaki University Graduate School of Biomedical Sciences, Nagasaki, Japan
2) Division of Radiation Biology and Protection, Center for Frontier Life Sciences, Nagasaki University, Nagasaki, Japan
3) Department of Physics, Bharathiar University, Coimbatore, India

Abstract. We screened urinary iodine (UI) concentrations in high background radiation areas of the Kanyakumari district of Tamilnadu, India. We collected 331 urine samples from three villages in the district: Chinna-Villai, Kadiyapatinam, and Pallam-Annai nagar. The median UI concentrations were 257, 262, and 454 µg/L in Chinna-Villai, Kadiyapatinam, and Pallam-Annai nagar, respectively. Only 27 samples showed mild or moderate iodine deficiency (<100 µg/L) and none showed severe deficiency (<20 µg/L). These findings indicate that iodine supplementation in the villages is sufficient, probably as a result of appropriate fortification of iodized salt in the region. Further screening, including morphological and functional analysis of the thyroid gland, will be needed to clarify the health effects of chronic low-dose radiation exposure attributable to residing in a high background radiation area.

Key words: India, Iodine, High background radiation area, Thyroid gland

Iodine is an essential micronutrient for normal human growth and development. Iodine deficiency can cause not only endemic goiter and cretinism, but also a wide spectrum of disabilities inducing deaf-mutism, mental and physical retardation, and various degrees of neuromotor dysfunction [1, 2]. Iodine deficiency is a global public health problem, particularly for pregnant women and young children [3]. In 1999, the World Health Organization (WHO) estimated that 130 of its 191 member states had significant problems with iodine deficiency disorders (IDD) [4]. Recently, WHO updated iodine status worldwide and concluded that there has been substantial progress in the last decade toward the elimination of iodine deficiency through iodine supplementation based on salt iodization [5]. However, careful follow-up of iodine status is definitely needed, especially in rural areas of developing countries.

Iodine deficiency has been a major public health problem in India. In 1995, an estimated 167 million people were at risk for iodine deficiency disorders (IDD) in India [6]. Based on the high risk of iodine deficiency, a complete ban on the sale of non-iodized salt has been implemented in India since 1995.

In Tamilnadu, in the southernmost portion of India, 24 of 29 districts were surveyed in the early 1990s and IDD was found to be endemic in all of them [7]. After the implementation of the iodine supplementation policy, a follow-up study was performed, and it was confirmed that in all districts except one, iodine deficiency was not endemic, which suggests the success of the universal salt iodization program in this area [8]. Evaluation of urinary iodine (UI) concentrations was not performed, however, in another five districts, including Kanyakumari district, which is known to be a high background radiation area due to rich deposits...
of monazite (a thorium-bearing mineral) in its coastal area [9]. Since it is well known that thyroid gland is a sensitive organ to radiation exposure, evaluation of thyroid status, including iodine supplementation status is important in this area.

In the present study, we screened the UI concentration in three villages in Kanyakumari district to evaluate the iodine status of residents of a high background radiation area in India.

Materials and Methods

Subjects and Samples

In 2008, spot urine samples were collected at three villages, Chinna-Villai, Kadiyapatinam, and Pallam-Annai nagar, which have been reported as high background radiation areas due to the presence of radionuclides such as thorium and uranium originating from monazite content in beach sands [10]. Urine samples were collected after obtaining written informed consents. Chinna-Villai is situated very close to the Manavalakurichi Plant of Indian Rare Earth Limited; Kadiyapatinam village is next village to the east of the Chinna-Villai village; and Pallam-Annai nagar is located about 5 km east of Kadiyapatinam village. The location of each village is shown in Figure 1. The populations of Chinna-Villai, Kadiyapatinam, and Pallam-Annai nagar villages are 1,300, 10,000 and 1,500, respectively. After collection, urine samples were kept at 4°C until the assay.

Measurement of UI

UI concentrations were measured by the simple micro plate method [11, 12], based on the Sandell–Kolthoff reaction, which incorporates both the digestion and the reaction into a micro plate format. Briefly, using a specially designed sealing cassette (Atom Kousan Co. Ltd, Tokyo, Japan) to prevent loss of vapor and cross-contamination among plates, ammonium persulfate digestion was performed in a 96-well micro titer plate (Micro Well; Nalge Nunc International KK, Tokyo, Japan) in a standard oven at 110°C for 60 min. After digestion, the mixture was transferred to a transparent micro plate, and the Sandell–Kolthoff reaction was performed at 25°C for 30 min. Finally, UI concentration in each well was measured by a micro plate reader at 405 nm. The sensitivity of this method was >10 µg/L.

Statistical analysis

UI concentrations were expressed as medians (25th-75th percentiles). According to WHO criteria, we defined mild iodine deficiency as 50-99 µg/L, moderate iodine deficiency as 20-49 µg/L, and severe iodine deficiency as less than 20 µg/L [4, 5].

Differences in UI concentration were evaluated by Mann-Whitney’s U-test. Probability values of less than 0.05 were considered indicative of statistical significance. All statistical analyses were performed using SPSS v16.0 software (SPSS Japan, Tokyo, Japan).

Results and Discussion

A total of 331 samples (86 from Chinna-Villai village, 204 from Kadiyapatinam village, and 41 from Pallam-Annai nagar village) were collected. UI concentrations were 257 (170-356) µg/L in Chinna-Villai village (Figure 2a), 262 (148-382) µg/L in Kadiyapatinam village (Figure 2b), and 454 (284-540) µg/L in Pallam-Annai nagar village (Figure 2c). There was no difference in UI concentrations between Chinna-Villai village and Kadiyapatinam village (p = 0.92). UI concentrations in Pallam-Annai nagar village were significantly higher than in Chinna-Villai village.
Fig. 2. Distribution of UI concentrations in a) Chinna-Villai village, b) Kadiyapatinam village and c) Pallam-Annai nagar village.
and Kadiyapatnam villages ($p < 0.001$ and $p < 0.001$, respectively). Twenty-six (8.2%) of 331 participants showed mild UI deficiency (50-99 µg/L), and only one (0.3%) showed moderate UI deficiency (20-49 µg/L, Table 1). No instances of severe iodine deficiency were observed.

In this preliminary study, we showed that residents of Chinna-Villai village, Kadiyapatnam village, and Pallam-Annai nagar village of Kanyakumari district, which are located in a high background radiation area, are currently not severely iodine deficient. The absence of severe iodine deficiency is probably due to appropriate distribution of iodized salt and relatively rich consumption of seafoods, because there are many fishermen in this area. Similar results have been reported from the neighboring state of Kerala, which is also a high radiation background area [13].

Recently, we assessed population dose due to natural background radiation exposure in Radhapuram and Nanguneri taluks in the neighboring district, and showed that the annual effective doses due to indoor gamma radiation to the population were 1.5 mSv and 1.36 mSv, which exceed the public dose limit (1.0 mSv/year) [14]. Although effects of chronic low-dose gamma radiation exposure are still unknown, careful evaluation of the health status of those residing in this area is needed.

Because it is well known that the thyroid gland is sensitive to external and internal radiation exposure, the evaluation of the thyroid gland should be an important part of health screening in this area. Experimental studies have shown that iodine deficiency may be an important modifier of the risk of radiation-induced thyroid cancer [15-17]. Iodine deficiency affects the dose received by the thyroid gland at the moment of exposure, and if maintained, can affect thyroid function in the time after exposure [18-20]. With this in mind, we screened UI concentrations in this area and showed that Kanyakumari district is not an iodine-deficient area. Further screening, including morphological and functional analysis of the thyroid gland, will be needed to clarify the health effects of chronic low-dose radiation exposure experienced by people residing in high background radiation areas.

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