

Long-term effect of iodized water and iodized oil supplementation on total goitre rate and nutritional status of school children in Ngargoyoso sub-district, Karanganyar regency, Central Java, Indonesia

Bambang Suprpto¹ and Yulia Lanti Retno Dewi²

1. Department of Nutrition, School of Medicine, Sebelas Maret University,
2. Department of Biology, School of Medicine, Sebelas Maret University.

Jl. Ir. Sutami 36 A Surakarta 57126, Indonesia

E-mail of the corresponding author: bsuprpto4@hotmail.co.id

Abstract

Background:

Ngargoyoso sub-district, Karanganyar regency, Central Java province, Indonesia, can be classified as severe IDD endemic area with TGR 51.9%. People get drinking water from spring-wells which contain no iodine. Drinking water has been distributed via pipelines directly to people's home.

Objectives:

The ultimate goal of the study was to supplement people's drinking water with iodine. The present study was designed to test hypothesis that iodine supplementation into drinking water was effective as iodized oil delivered in capsules.

Methods:

Eight hundred school children from year two and year four in Ngargoyoso sub-district were randomly assigned into two groups. The first group (N=407) received 100 mg iodine capsules (Yodiol™, Kimia Farma, Indonesia) and the second group (N=393) received 100 µg KIO₃ daily via drinking water. Urinary iodine excretion (UIE) was measured using Method A (ammonium persulfate) in an accredited IDD Laboratory in Magelang, Central Java, Indonesia. Goitre prevalence was measured by palpation method. Total goitre rate (TGR) is the sum of grade 1 and grade 2. Nutritional status was measured as z-score of weight for age, height for age and weight for height using WHO Anthro (2005). Statistical analysis was performed using SPSS for Windows release 17.0 (Chicago, IL, USA).

Results:

Urinary iodine excretion increased in both groups. In the capsule group there was an increase of UIE from 244.16 (±104.37) µg/L to 522.91 (±315.83) µg/L (p<0.001), whereas UIE in the KIO₃ group slightly increased from 210/94 (±201.45) µg/L to 225.70 (±93.28) µg/L (p<0.05). Total goitre rate (TGR) decreased from 51.9% at basal to 46.19% and 38.5% after three months and six months supplementation in the capsule group. While in the KIO₃ group TGR decreased to 42.49% and 34.35% after three and six months, respectively. Comparison between groups showed no significant differences in TGR (p>0.05). Nutritional status was not affected by iodine supplementation in both groups.

Conclusion:

Iodine supplementation into drinking water was effective as iodized oil in capsule in reducing goitre prevalence among school children in Ngargoyoso sub-district, Karanganyar regency, Central Java Province, Indonesia.

Keywords: *iodized water, iodized oil, goitre prevalence, nutritional status.*

1. Introduction

Ngargoyoso sub-district is an IDD pocket area in Central Java, Indonesia. Total goitre rate in 1996 was 29% and increased steeply to 51.9% in 2010 (Suprpto et al, 2010). In 2004 the government of Indonesia released decentralization decree, since then the responsibility was distributed until district level, including IDD elimination program. Unfortunately, the local government did not allocate budget for iodized capsules since several years ago.

Drinking water in Ngarogoso sub-district contains no iodine (Dewi, 2010) and iodized salt was consumed only by 61% household. ICCIDD/WHO (2007) recommended other means whenever coverage of iodized salt in the community below 90%. Iodine supplementation into drinking water has been implemented successfully in Mali (Fisch et al, 1993). Pandav et al (2000) conducted an economic evaluation of water iodization program in Thailand. They concluded that water iodization was cost effective in reducing total goitre rate among school children in Thailand, even cheaper when iodized water consumed by all member of household. Recently, Dewi et al (2012) successfully increased urinary iodine excretion (UIE) by supplementing drinking water presented in *kendi* with KIO₃, and subsequently increased intelligence score of preschool children age 25-59 months in Ngarogoso sub-district, Karanganyar regency, Central Java province, Indonesia. Iodine supplementation trial on school children using iodine capsule successfully increased cognitive performance in several countries (van den Briel et al, 2000; Zimmermann et al, 2006). Iodine supplementation also reduced thyroid volume and goitre prevalence, while nutritional status was not affected (Bautista et al, 1982). The present study was designed to test hypothesis that iodine supplementation into drinking water was effective as iodized oil capsule.

2. Subjects and Methods

2.1. Study location

The study took place in the rural area of Ngarogoso sub-district on the high slope of Mount Lawu, Central Java, Indonesia, at an altitude between 650 and 1100 meters above the sea level. It has some asphalt roads, traditional markets, some electricity, 58 integrated health posts and a health center. The most remote area has no access for car. It consists of 9 villages with inhabitant about 30.000 people living from subsistent farming. People drink water from spring wells via pipelines directly to their homes. The water contains no iodine. Iodized salt is widely distributed in the markets with higher price than un-iodized one. Only 61% households used iodized salt for cooking. Since the year 2004 iodized oil has been withdrawn from Indonesia IDD elimination program, including in the study area. Total goitre rate (TGR) in Ngarogoso sub-district increased steeply from 29% in 1996, to 32% in 2006, and 51.9% in 2010 after stopping the supply of iodized capsules. There were 20 state-owned elementary schools with \pm 3000 students in the sub-district. All schools were included in the study.

2.2. Subjects

Eight hundreds school children at year two and year four were included in the study. Cluster random sampling was used to allocate school children into two groups. Group I received 100 mg iodine capsule and Group II received 100 μ g KIO₃ in drinking water daily. Potassium iodate was used as it does not change the color, taste and odor.

2.3. Study protocol

List of all (20 schools) state-owned elementary school in Ngarogoso sub-district was used as baseline data. Then, the schools were numbered and used as clusters. Cluster random sampling technique was used to allocate the schools into two groups. The first group (N=407) was given iodized oil in capsule containing 100 mg iodine. The second group (N=393) received 100 μ g KIO₃ with drinking water in two glasses during school time (there are two breaks daily, six days a week). Student from year two and year four were chosen as subjects of the study, because their goitre prevalence has been measured a year before when they were in year one and year three, respectively. Two doctors in charge at Ngarogoso Health Center undertook palpation of the thyroid gland. Both of them have been trained in thyroid palpation at Research and Development Center on IDD, Magelang, Central Java, Indonesia. Teachers were recruited to ensure that the iodine supplements were taken by the students. Iodized capsules were given by the doctors directly into subject's mouth. Palpation of thyroid, weight, height and urinary iodine excretion were taken at three and six months after iodine supplementation (see Figure 1). The study was undertaken between January and August 2012.

2.4. Urinary iodine measurement

Two hundred students (taken randomly) of each group were asked to collect their urine at basal and three months and six months iodine supplementation. Urinary iodine excretion (UIE) was measured using Method A-ammonium persulfate digestion (WHO, 2007). Casual urine samples were taken without preservative and refrigeration in plastic bottles (50 ml with sealed cap) in the morning before starting the class hour, and then sent to IDD laboratory at Magelang, Central Java on the next day. Results were reported in μ g/L urine.

2.5. Palpation of thyroid

The student to be examined stands in front of the doctor and the asked to look up and fully extend his/her neck. The doctor palpates the thyroid by gently sliding her own thumb along the side of the trachea between the cricoids cartilage and the top of the sternum. Both sides of trachea are checked. The size and consistency of the thyroid

gland are carefully noted (WHO, 2007). Goitre is graded according to the classification as follow:

Grade 0 No palpable or visible goitre.

Grade 1 A goitre is palpable, but not visible, when the neck is in the normal position.

Grade 2 A swelling in the neck that is clearly visible when the neck is in a normal position and is consistent with an enlarged thyroid when the neck is palpated.

Total goitre rate is the sum of grade 1 and grade 2.

Result was reported in % of the subjects examined.

2.6. Anthropometric measurements

Weight was recorded on a calibrated mechanical bathroom scale to the nearest 0.1 kg (Krupps, Ireland) after zeroing for each measurement. Children were lightly clothed and had removed their footwear. Height was recorded using a microtoise (Statometer™, Indonesia) and measured to the nearest 0.1 cm. Each child stood with his buttocks, heels and back against the wall and his head in the Frankfurt plane. Data was analyzed using WHO-Anthro software package (adapted for Indonesia, 2005) and the results were reported as z-scores for weight/age, height/age and weight/height.

2.7. Supplements

To provide 100 µg iodine/L drinking water, the following procedure was used: 24 g of KIO₃ diluted with adding 725 ml distilled water. This solution is then poured into 24 plastic bottles of 30 ml each. Two drops of this solution is added to 10 L of drinking water. This provides 200 µg iodine per liter of drinking water (Pandav et al, 2000). Thus, to obtain 100 µg iodine per liter of drinking water, we put one drop of the solution to 10 liters of drinking water. The drinking water was kept in five liter pot. Each student provided a glass of 250 ml. They were asked to drink two glasses every day during break time. The supplement does not change the color, taste and odor of the drinking water. The supplement was given to the iodized water group. Iodized oil (Yodiol™, Kimia Farma, Indonesia), 100 mg/capsule was given at the beginning of the study to the iodized oil group.

2.9 Statistical analysis

Results were expressed as the mean ± standard deviation. To see the difference between baseline and post-treatment in each group a paired *t*-test was used. For comparison between groups an independent *t*-test was used. Another test was used when appropriate. All statistical analysis was performed using SPSS for Windows, release 17.0 (Chicago, IL, USA).

2.10 Ethical considerations

The study was approved by the Ethical Review Committee, School of Medicine, Sebelas Maret University. The students, the parents and the head masters were informed about the nature of the study and agreed to participate in the study.

3. Results

Total goitre rate from last survey was used as basal goitre prevalence for both treatment groups, i.e. 51.9%. (Suprpto et al, 2010). After three and six months supplementation TGR decreased as shown in Table 1. Mean urinary iodine excretion in both groups increased significantly as shown in Table 2. Table 3 shows z-score W/A, H/A and W/H in both groups after three and six month iodine supplementation. The results showed that nutritional status of the schoolchildren in Ngargoyoso sub-district was fairly below the WHO (2005) standard, and no improvement after iodine supplementation.

4. Discussion

Ngargoyoso sub-district has been known as an IDD endemic area for several decades (Suprpto et al, 2010; Dewi et al, 2012). It is located on the high slope of Mount Lawu at around 900 m above sea level, with high rainfall. People's drinking water lacks of iodine and contaminated by E.coli (Dewi et al, 2012). Recently, TGR increased steeply due to combination of lack of iodine in water, low consumption of iodized salts and the local government policy banning iodized capsule (Suprpto et al, 2010; Dewi et al, 2012). Since the year 2004 the government of Indonesia withdrew iodine capsules from its IDD elimination program, so that school children and pregnant women in Ngargoyoso sub-district relied their iodine intake on iodized salt. Unfortunately, some problems with iodized salt still exist, namely: price, coverage, distribution, and low iodine concentration (Djokomoeljanto et al, 2004). Only 61% of households in Ngargoyoso sub-district used iodized salts. Semba et al (2008) found only 81.1% of iodized salt in the market containing iodine >30 ppm. People's household expenditure was less than \$100 monthly, and only a quarter of it expended for food (Dewi, 2012). Eastman and Zimmermann (2009) reviewed

vehicles for iodine supplementation. They found that there are some effective ways to supplement iodine including iodized oil, iodized bread, iodized salt and iodized water. Iodized water successfully reduced goiter prevalence in Thailand (Pandav et al, 2000). Dewi (2012) made a comparison of various methods of iodine supplementation. She concluded that iodine supplementation into drinking water was effective and efficient.

School children (6-12 years) is the preferred group for thyroid palpation, as it is usually easily accessible (WHO, 2007), Thyroid gland of the younger child is more difficult to be examined. Epidemiological criteria for assessing severity of IDD based on the prevalence of goiter in school age children has been set by WHO (2007) as the following:

TGR 0.0 – 4.9%	Non endemic
5.0 – 19.9%	Mild
20.0 – 29.9%	Moderate
≥ 30%	Severe

According to the criteria, Indonesia has been classified as a country with mild IDD (TGR 11.1% in 2003 survey, Atmarita (2005). However, there are many IDD pocket areas spread out the country, and Ngargoyoso sub-district is one of them with TGR 51.9% (Suprpto et al, 2010). Lacks of iodine in drinking water and food consumed is the main cause of goiter. In an iodine deficient area like Ngargoyoso sub-district the only way to supply iodine in the population is to provide iodine from outside. Meanwhile, iodized salt is in progress in the sub-district but not enough to prevent goiter in school children. Iodized capsule has been withdrawn from Indonesia IDD elimination program. Thus, the present study was design to prove that iodized water can replace iodized capsule in Ngargoyoso sub-district. The premise that iodized water (drop method) is cost effective in reducing prevalence of goiter (Pandav et al, 2000) is compatible with people's socioeconomic condition in the study area. People get drinking water from spring wells free from the nature. The cost of KIO₃ is less than \$0.001 per day per person (Dewi et al, 2012). Educating people to boil the drinking water will reduce contamination with E.coli (Dewi, 2012).

Three months after iodine supplementation urinary iodine excretion increased in both groups (Table 2). Iodized oil group showed greater increment ($p < 0.001$) than iodized water group ($p < 0.05$), however, the trend of reducing the prevalence of goiter was greater in iodized water group (Table 1). The puzzle could not be easily answered. Higher urinary iodine excretion means excess of iodine intake. In adults, excess of iodine intake could be harmful, but not among children (Yang et al, 2007). Urinary iodine excretion is the main indicator to be used to assess iodine status of a population (WHO, 2007). Pardede et al, (1998) concluded that urinary iodine excretion is the most appropriate indicator to be used in the field condition at district level. It seems that urinary iodine excretion reflects iodine status in the community, therefore an increase in urinary iodine excretion will reduce total goiter rate as expectedly. Both supplemented groups showed substantial reduction in total goiter rate (Table 1) after three and six month iodine supplementation. Another puzzling result was shown in Table 2. Although means of urinary iodine excretion at basal was much higher than the epidemiological criteria for assessing iodine nutrition based on median urinary iodine concentrations of school age children (≥ 6 years) set up by WHO (2007), i.e. $> 200 \mu\text{g/L}$ and classified as above requirements, the total goiter rate at basal was 51.9%. Even after six month iodine supplementation in both groups the total goiter rate was still high and classified as severe endemic (WHO, 2007), despite a substantial reduction in TGR (Table 1). Zimmermann (2007) argued that several nutrient influence the utilization of iodine in the thyroid gland i.e. vitamin A, iron, selenium and protein. Iodine deficiency combines with lacks of these nutrients will affect the prevalence of goiter.

Nutritional status is the results of nutrient intakes and utilization by the body. Iodine via thyroid hormone influences the metabolism of energy, carbohydrate and protein. By this way, it affects somatic growth. In the study, we measured nutritional status as z-score of weight for age, height for age and weight for height using WHO software (2005). The results showed in Table 3. School children in Ngargoyoso sub-district could be classified as below WHO standards. After three and six month iodine supplementation there was no improvement in nutritional status. Solon et al (2003) also found no improvement in nutritional status even they used multiple micronutrients with $48 \mu\text{g}$ iodine. Manger et al (2008) in Thailand also failed to improve nutritional status of school children supplemented with multiple nutrients including $50 \mu\text{g}$ iodine. Rosado (1999) found stunted children at least deficient in two nutrients. Wachs et al (2005) concluded that maternal education and intelligence predict diet and nutritional status of her children. Waterlow (1992) showed that a longer time is needed to improve linear growth. It seems that six month is too short to observe an improvement in linear growth. It becomes clear now that nutritional status of children reflects nutrient intakes and socioeconomic condition as well.

In summary, the present study reveals that:

1. Iodized oil in capsule and iodized water in drinking water increased urinary iodine excretion above the standard set up by WHO (2007) after three month supplementation in school children at Ngargoyoso sub-district, Karanganyar regency, Central Java province, Indonesia.
2. Both iodized oil and iodized water reduced total goiter substantially, but the total goiter rate in Ngargoyoso sub-district is still very high. To eliminate iodine deficiency disorders in the study area much efforts is needed.
3. Nutritional status of school children was fairly below WHO (2002) standards.
4. Iodine supplementation for three and six month failed to improve nutritional status of school children in the study area
5. Many factors influenced the nutritional status which beyond the scope of the study.

5. Conclusion

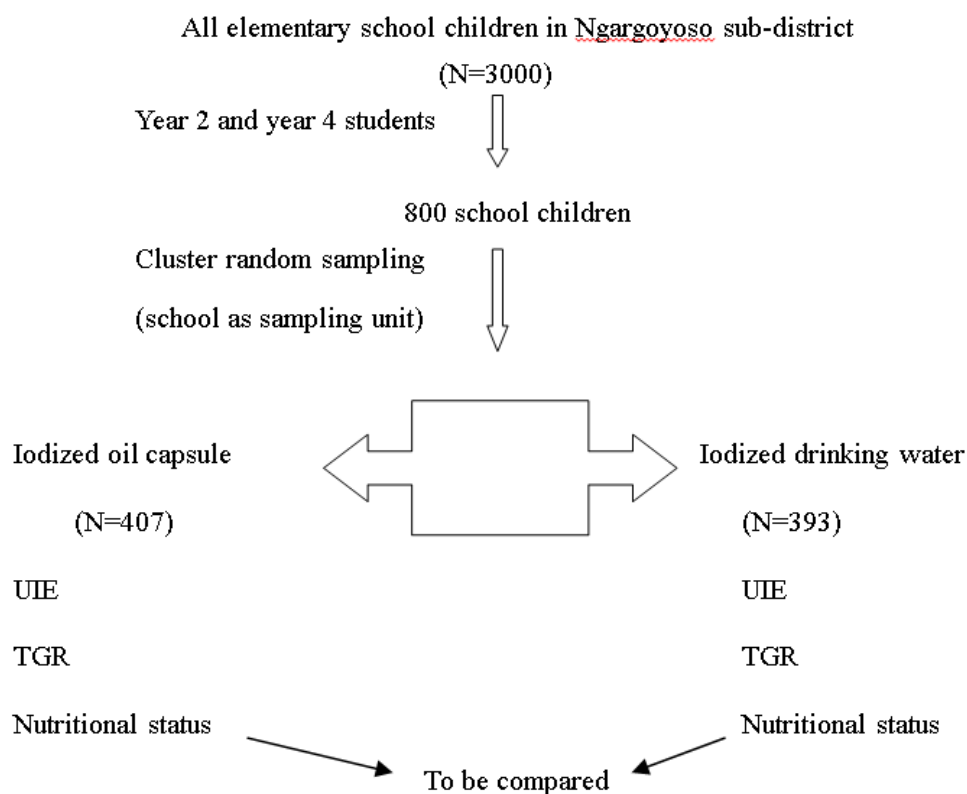
Iodine supplementation into drinking water is effective as iodized oil capsule in reducing the total goiter rate, but could not improve nutritional status of school children in the study area.

Acknowledgements

We would like to thank all students and teachers in the study area who are eagerly participating in the study. We also would like to thank Dr. Suryani, M.Biotech, Head of IDD Laboratory Magelang, Central Java and Dr.Retno Sawartuti, M.Kes, Head of The Health Center at Ngargoyoso sub-district for their help. This study was supported by the Ministry of Education Republic of Indonesia contract number: 247a/UN27.11/PN/2012.

References

- Atmarita. (2005). *Nutrition Problems in Indonesia*. An integrated International Seminar and Workshop on Lifestyle-Related Disease. Yogyakarta: Gajah Mada University, 19-20 March, 2005.
- Bautista A, Barker PA, Dunn JT, Sanches M, and Kaizer DL. 1982. The effect of oral iodized oil on intelligence, thyroid status, and somatic growth in school-age children from an area of endemic goitre. *American Journal of Clinical Nutrition*, 35:127-34.
- Department of Health, Republic of Indonesia. (2000). Penanggulangan GAKY di Indonesia.
- Dewi YLR. 2012. *Pengaruh iodisasi air minum dalam kendi terhadap kadar iodium urin dan kecerdasan anak usia 25-59 bulan di kecamatan Ngargoyoso, Karanganyar, Jawa Tengah*. Doctoral Thesis. Universitas Sebelas Maret.
- Dewi YLR, Mudigdo A, Suranto and Murti B. (2012). Iodine supplementation into drinking water improved intelligence of preschool children aged 25-59 months in Ngargoyoso sub-district, Central Java, Indonesia: A randomized control trial. *Journal of Biology, Agriculture and Healthcare*, 2(5):134-142.
- Djokomoeljanto, R.S., & Untoro, R. (2004). IDD Control in Indonesia. In: *Towards the Global Elimination of Brain Damage Due to Iodine Deficiency (Hetzel BS eds)*. New Delhi, Oxford University Press.
- Manger MS, McKenzie JE, Winichagoon P, Gray A, Chavasit V, Pngcharoen T, Gowachirapant S, Ryan B, Wasantwisut E and Gibson RS. 2008. A micronutrient-fortified seasoning powder reduce morbidity and improves short term cognitive function, but has no effect on anthropometric measures in primary school children in northeast Thailand: a randomized controlled trial. *American Journal of Clinical Nutrition*, 87:1715-22.
- Ministry of Health and Social Welfare. (2000). *Iodine Deficiency Disorders (IDD) Control Program in Indonesia*.
- Pandav, C.S., Anand, K., Sinawat, S., & Ahmed, F.U. (2000). Economic evaluation of water iodization program in Thailand. *Southeast Asian J Trop Med Publ Health*, 31, 761-768.
- Pardede LVH, Hardjowasito W, Gross R, Dillon DHS, Totoprayogo, Yosoprawoto M, Waskito L, and Untoro J. 1998. Iodine excretion is the most appropriate outcome indicator for iodine deficiency at field conditions at district level. *Journal of Nutrition*, 128:1122-1126.
- Rosado JL. 1999. Separate and Joint Effects of Micronutrient Deficiencies on Linear Growth. *Journal of Nutrition*, 129:531S - 533S.
- Semba RD, de Pee S, Hess SY, Sun K, Sari M, and Bloem M. 2008. Child malnutrition and mortality among



families not utilizing adequately iodized salt in Indonesia. *American Journal of Clinical Nutrition*, 87:438-44.

Wachs, T.D., Creed-Kanashiro, H., Cueto, S., & Jacoby, E. (2005). Maternal Education and Intelligence Predict Offspring Diet and Nutritional Status. *J Nutr*, 135, 2179-2186.

World Health Organization. 2007. *Assessment of iodine deficiency disorders and monitoring their elimination: A Guide for Programme Managers*. Third edition.

Yang F, Shan Z, Teng X, Li Y, Guan H, Chong W, Teng D, Yu X, Fan C, Dai H, Yu Y, Yang R, Li J, Chen Y, Zhao D, Mao J and Teng W. 2007. Chronic iodine excess does not increase the incidence of hyperthyroidism: a prospective community-based epidemiological survey in China. *European Journal of Endocrinology*, 56:400-408.

Zimmermann, M.B., Conolly, K., Bozo, M., Bridson, J., Rohner, F., & Grimci, L. (2006). Iodine supplementation improves cognition in iodine-deficient schoolchildren in Albania: a randomized, controlled, double blind study. *Am J Clin Nutr*, 83, 108-114.

Zimmermann MB. 2007. *Key Barriers to Global Iodine Deficiency Disorder Control; A Summary*. A2Z Project. USAID.

Figure 1. Flow diagram of the study

Table 1 Total goitre rate at three and six months after iodine supplementation

Treatment group	TGR 3 months (%)	TGR 6 months (%)
Yodiol™ capsule (N= 407)	46.19	38.50
KIO3 into drinking water (N= 393)	42.49	34.35

p > 0.05

Table 2. Mean Urinary iodine excretion at basal and 3 month after iodine supplementation

Treatment group	UIE basal ($\mu\text{g/L}$)	UIE 3 months ($\mu\text{g/L}$)
Yodiol™ capsule (N= 196)	244.16 (104.37)	522.91 (315.83)*
KIO3 into drinking water (N=195)	210.94 (201.45)	225.70 (93.28)**

(Mean (\pm SD))
 *p<0.001
 **p >0.05

Table 3. Nutritional status after three and six month iodine supplementation (z-score)

Treatment group	z-score weight/age	z-score height/age	z-score weight/height
Yodiol™ capsule (3 mo)	-1.115 (\pm 0.898)	-1.320 (\pm 0.830)	-0.180 (\pm 0.993)
KIO3 in water (3 mo)	-1.207 (\pm 0.867)	-1.486 (\pm 0.860)	-0.330 (\pm 0.860)
Yodiol™ capsule (6 mo)	-1.121 (\pm 0.869)	-1.337 (\pm 0.825)	-0.003 (\pm 0.933)
KIO3 in water (6 mo)	-1.202 (\pm 0.857)	-1.479 (\pm 0.847)	-0.037 (\pm 0.809)

p>0.05