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Research Article

Iodine Deficiency in a Mountainous Area of Central Java, Indonesia in the Perspective of Ecology

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Iodine status measured as urinary iodine excretion in school children has improved in recent years in Indonesia, including Central Java province. However, the Total Goiter Rate (TGR) in the Ngargoyoso sub-district was 51.0% in 2010.The objective of this study was to identify environmental factors that may affect iodine deficiency in this sub-district. An ecological perspective was used as a conceptual framework to conduct cross sectional studies between 2010 and 2015. Data on Total goiter rate was collected from 800 schoolchildren aged 8-10 years using palpation of the thyroid gland. The urinary iodine excretion was carried out by using acid digestion Sandell- Kolthoff reaction on 371 preschool children and 153 pregnant women. Iodized salt was determined by Iodina test ™ (Kimia Farma, Indonesia). Hemoglobin concentration was measured by Sahli Method. A direct method with 2% eosin in alcohol was used to look for soil helminthes eggs. Microbiological examination was done on drinking water to find out *Escherichia coli.* TGR in school children was 51.0%. Urinary iodine excretion (UIE) < 100µg/L in preschool children was 23.3%. UIE <150µg/L among pregnant women was 54.3%. Iodine was not detected in the drinking water, but contaminated by *Escherichia coli*. Soil helminthes infestation i.e. *Ascaris lumbricoides, Trichuris trichiura* or *Necator americanus* were found in 46% of feces examined. The prevalence of anemia in school children were 94%. Environmental factors may influence iodine deficiency in Ngargoyoso sub-district.

Key words: ecology, environmental factors, iodine deficiency, total goiter rate, Central Java.

INTRODUCTION

Central Java is one of the most populated provinces in Indonesia, with more than 25 million inhabitants. It has several mountainous area and volcanoes. One of them is Ngargoyoso sub-district, which is known as endemic area of iodine deficiency, Iodized oil injections were given to children and women at bearing age until 1994. In 1995 the Government of Indonesia (GoI) replaced iodized oil injections with iodized oil capsules with the same target groups. However, in 2004 GoI released decentralization decree, where budget allocations, including health budgeting is under district administration responsibility. Consequently, there is no budget for buying iodized oil capsules. Since then, people in the region rely their iodine intake on iodized salt in the market Urinary iodine excretion in Indonesia has achieved sufficiency level at national level, however The Total Goiter Rate (TGR) in Ngargoyoso sub-district is still very high. The aim of the study was to identify environmental factors that may affect iodine deficiency in the region.

Ethics approval

All experiments were approved by the Ethical Review Committee School of Medicine, Sebelas Maret University. The mothers and the school principals agreed to participate in the study and gave their informed consents on behalf the children.

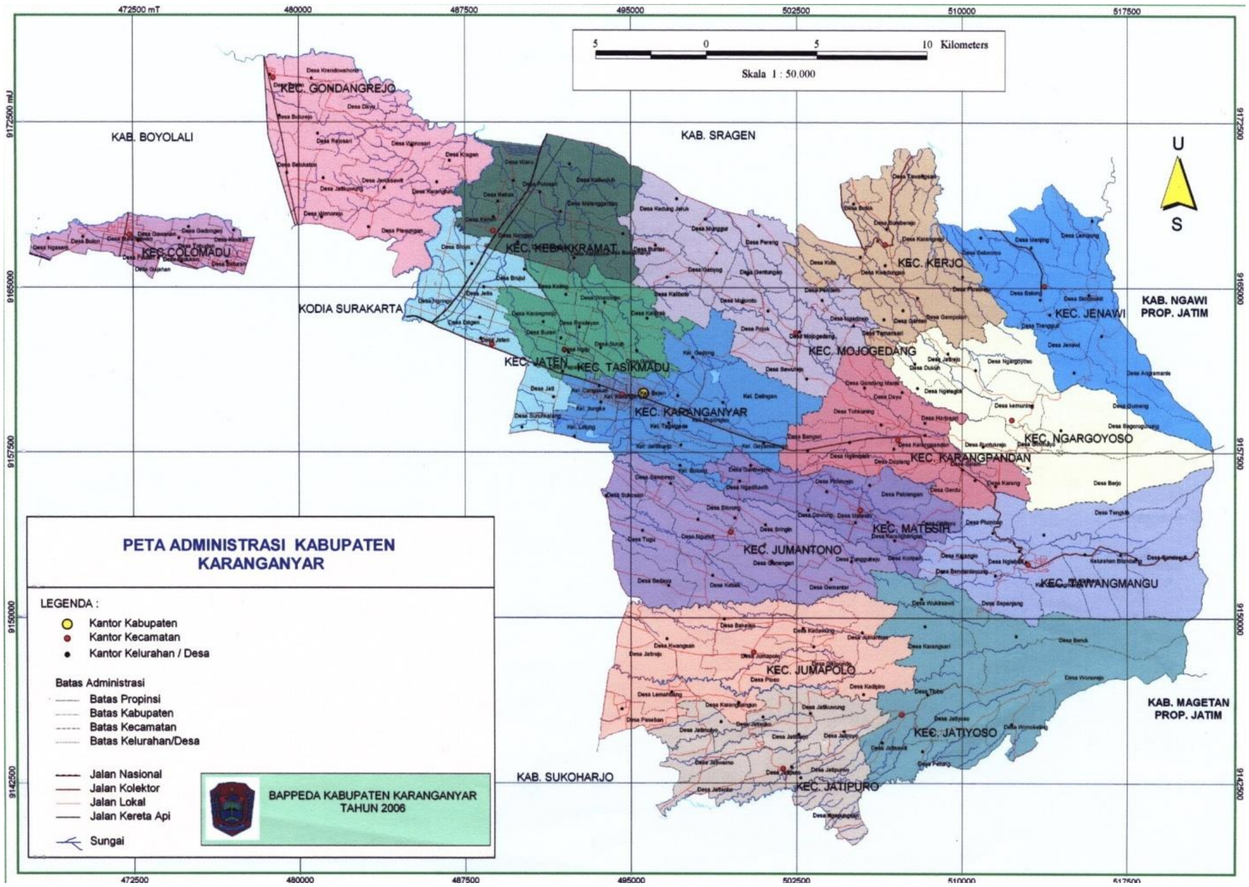

Figure 1. Map of Karanganyar district. White color is Ngargoyoso sub-district.

MATERIAL AND METHODS

Research setting

Ngargoyoso sub-district is a part of Karanganyar district (Figure 1). It is located on the high slope of Mount Lawu, between 900 and 1100 meters above the sea level. It has around 35,000 inhabitants with a health center, three doctors and twenty state owned elementary schools. Two traditional markets, some asphalt roads and electricity served the center of sub-district. The most remote area has no access for car. People get their drinking water from spring wells. Paddy, cassava, cabbage, soybean and carrot are locally grown and consumed in the region. The study was conducted between 2010 and 2015.

Conceptual framework

An ecological perspective model was used as a conceptual framework. According to this model iodine deficiency is resulting from physical factors, biological factors, social factors and cultural factor across the region (Figure 2). Physical environments that may affect iodine deficiency are topography, soil type, deforestation, rainfall and erosion. Among biological factors is E.coli contamination of drinking water, since cabbage which are consumed almost every day contains progoitrin. E.coli has capacity to convert progoitrin into goitrin with its goitrogenic activity. Anemia is highly prevalent in school children in the region. Iron deficiency inhibits the utilization of iodine in producing thyroid hormones. Soil helminthes may also impede iodine absorption.

Social environments include national, district and local level that may influence iodine status in the community. Cultural environments are also scrutinized i.e. ignorance, subsistence farming, monotonous meal plan and cooking practices.

Iodine status determination

Total Goiter Rate

Iodine status of the region was determined by using TGR among schoolchildren and urinary iodine excretion among preschool children and pregnant women. Eight hundred schoolchildren (403 boys and 397 girls) aged 8-10 years were screened for goiter. They are students from year two and year four registered at 20 elementary state-owned schools. Why TGR was chosen? This method is cheap, easy to do and still commonly used in the population study. To minimize inter-observer variation in this study, we used only two doctors to carry out the palpation. These doctors were trained on palpation of the thyroid glands at the IDD Research and Development Centre, Magelang, Central Java. The children to be examined stand in front of the examiner; they asked to look up and fully extended his neck. The examiner palpated the thyroid gland by gently

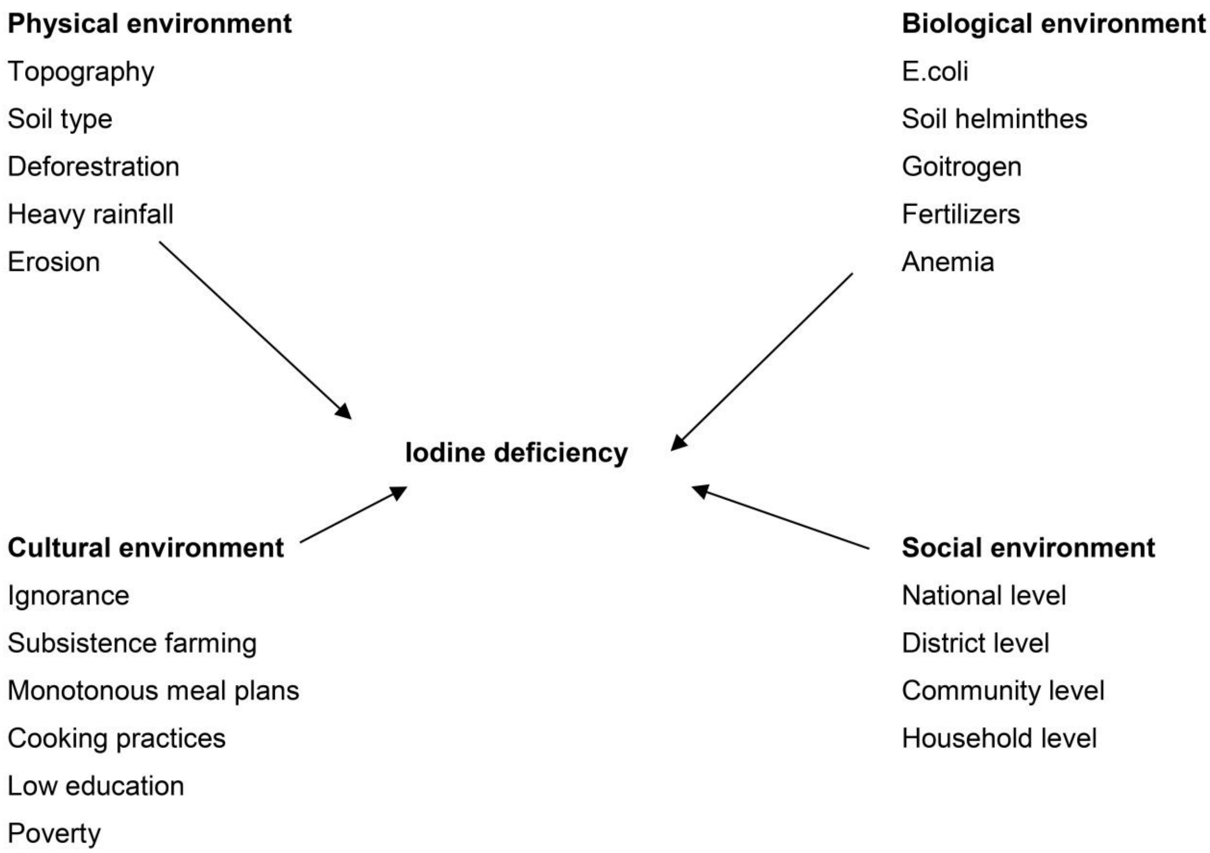

Figure 2. Conceptual framework for the study on the Ecology of Iodine Deficiency Disorders in Ngargoyoso sub-district, Central Java, Indonesia.

sliding her owns thumb along the side of the trachea between the cricoids cartilage and top of the sternum. Both sides of the trachea are checked. The size and consistency of the thyroid gland are carefully noted. Goiter was classified according to WHO classification (2007) as the following:

Grade 0: the thyroid gland is neither palpable nor visible.

Grade 1: the thyroid gland is palpable, but not visible when the neck in a normal position.

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

Total Goiter Rate (TGR) is the sum of Grade 1 and Grade 2, divided by all children palpated.

At the same period three hundred and seventy-one preschool children aged 24-59 months (all preschool children) and 153 pregnant women (all pregnant women registered at the health center). Casual urine samples were taken without preservative and refrigeration in plastic bottles in the morning, and then sent to IDD Research and Development Laboratory and Magelang, Central Java at the same day. The urinary iodine excretion was measured using acid digestion Sandell Kolthoff reaction as proposed by WHO (2007). The results expressed as µg/L. Cut off points for preschool children is100 µg/L and150 µg/L for pregnant women.

Iodine in salt

The school children were asked to bring salts which are used in their own home. A rapid kit test for iodine in salt called Iodina™ Test produced by Kimia Farma, Indonesia was used to screen whether salt for human consumption in the market have been iodized.

Blue color means enough iodine, white color means no iodine at all.

Hemoglobin measurements

Determination of hemoglobin concentrations were established by Sahli method. Twenty cubic millimeter capillary blood were drawn by finger pricked. Add this blood to tube containing 0.1N hydrochloric acid, then mix carefully and read after 5-7 minutes. Add water until the color of the mixture similar to the color of Sahli's hemoglobinometer. Cut off for school child has been set out at 12 g/dl.

Soil helminthes

Soil transmitted helminthes eggs were detected by using a direct method with 2% eosin in alcohol. A small amount of feces was directly stained by eosin on the object glass. A light microscope was used to detect egg of *A.lumbricoides*, *T.trichiura*, and *N.americanus*.

Escherichia coli contamination

Escherichia coli are detected in the drinking water consumed by people at Ngragoyoso sub-district by Conventional Method at an accredited laboratory in Karanganyar district. Interview with schoolchildren on meal pattern were carried out during school day.

Government policy in IDD eradication

Social factor that may influence iodine deficiency in the region comes at the national level. The government changed its policy from iodized oil injection to oral iodized oil and then to Universal Salt Iodization (USI). It reduced the availability of iodine in the community.

Secondary data

All secondary data were retrieved from official report published in Karanganyar district's website (www.karanganyarkab.go.id)

RESULTS

Summary of the results can be seen in Table 1. Both UIE and TGR revealed that iodine deficiency still exists in the region and alarming for prompt actions. Environmental factors also took part in the pathogenesis of iodine deficiency in the study area.

Table 1: Summary of the findings

Location	High slope of Mount Lawu, Central Java, Indonesia
Topography	Altitude 900 – 1100 meter above sea level Heavy rainfall Erosion and landslides
Demography and socioeconomic status	35.845 inhabitants Subsistence farming Rice, cassava, carrot, soybean, cabbage locally grown 24.7% below poverty line (1 USD/capita) 50% spent 6 years in school
Health facilities and budget	One Health Centre, 3 doctors
Allocation	Decentralization since 2004
Iodine status	TGR (school children) 51.0% UIE (preschool children) 23.3% < 100 µg/L UIE (pregnant women) 54.4% < 150 µg/L
Source of dietary iodine	Iodized salt, 12.6% contain < 30 ppm Crystalline salt, un-iodized sold in the market Iodized salt has higher price than crystalline salt Small dried fish (occasionally)
Goitrogens in diet	Escherichia coli in drinking water Goitrogenic foods: Soybean, cassava, cabbage
Nitrogen fertilizers	
Cooking practices	Using un-iodized salt (29%) Improper cooking practices

DISCUSSION

Although the relation of iodine deficiency and endemic goiter is well established, in fact, the distribution of endemic goiter is also influenced by environmental factors i.e. physical, biological and social factors. These environmental factors may act in three different ways i.e. by affecting the availability of iodine, by affecting nutritional requirements of the host, and by affecting the intake of iodine. Current paradigm in combating iodine deficiency has been focused to iodine supplementation either via iodized oil capsules or iodized salt (WHO, 2007). This approach showed a great success in many parts of the world. However, recent analysis of the latest WHO review tracing an increasing trend of TGR between 1993 and 2003, which is estimated 31.7% increase (Kotwal, 2010). In Indonesia TGR also increased from 9.8% in 1998 to 11.1% in 2003, in spite of an intensified IDD eradication program for five years (Atmarita, 2005). Further analysis showed that from 268 districts in Indonesia the TGR was unchanged in 150, 68 worsened an only 50 districts improved after five years intensified IDD eradication program (Atmarita, 2005). This program mainly based on the usage of iodized salt in Indonesia. Even in Switzerland, the country with history of success in salt iodization, now there is a tendency that iodine intakes are currently at the lower end of the recommended range in school children and women at bearing age (Zimmermann, 2013). It seems that the prevention of IDD goes beyond iodizing salt (Dugassa & Negassa, 2012).

Current paradigm of IDD eradication program can be simplified as the equation below:

Iodine deficiency + Iodine supplementation = Iodine sufficiency

This paradigm assumes that iodine deficiency in a particular area is given and unchangeable: i.e. soil and water in this area are lack of iodine. However, Johnson (2003) proposed two folds approaches in controlling the iodine in an environment. The first is to manage efficiently the iodine that already exists. Secondly, if needed, to increase iodine in the environment by adding additional supply of iodine. He believed that, even, a small changes could lead to a significant impact on the iodine status of local community for a longer period (Johnson, 2003). In Ngargoyoso sub-district several physical environments are difficult to change like climate and topography, but erosion and deforestation can be prevented. The district administration should release regulations and educate people not to cut trees in preventing flooding and landslides.

There are several ways to manage the environmental natural iodine effectively i.e. changing crops grown, using livestock grazing to concentrate iodine, improving the soil's ability to fix iodine, finding alternative sources of more iodine-rich water, preventing the removal of iodine by flooding (Johnson, 2003). However due to poverty, it would be difficult for people in Ngargoyoso sub-district to implement these proposed interventions. Adding iodine to the environment i.e. via drinking water directly to preschool and school children was effectively reduce the prevalence of iodine deficiency in Ngargoyoso sub-district (Dewi, 2016). However, as a public health measure, the sustainability of this iodine supplementation is questionable (Dugassa & Negassa, 2012). Biological environments found in Ngargoyoso sub-district (Figure 1) is modifiable. *Escherichia coli* in the drinking water are easily treated by boiling. Using *kendi* as drinking water container is one alternative that has been on trial successfully (Dewi, 2012), because the water should be boiled before placing in *kendi.*.Our result showed that the prevalence of soil helminthes among school children was 46%. Goitrogen in local food is difficult to eliminate, because it is linked with subsistence farming and climate. Cabbage, for instance, is easily grown in mountainous area with cool climate. Cabbage is containing progoitrin, and *E.coli* has ability to change progoitrin into goitrin with its goitrogenic effect..

Fertilizers used in Ngargoyoso sub-district containing nitrogen with its goitrogenic effect (Simescu et al, 2000). In Indonesia, the price and distribution of fertilizers are under control of the government. Social environment at the national level, such as the policy of salt iodization as the only vehicle for iodine supplementation in Indonesia brings about some problems. Total salt requirement is 2.6 million tons, currently. About half should be imported, and easily controlled for its iodine content.

The government of Indonesia (GoI) has launched SNI 01-3556-2000 for iodized salt. This SNI was revising in 2010 through SNI 3356-2010. It should contain 30 ppm of iodine for human consumption. However, law enforcement in this area is very weak. For example, in 2004 there were 366 salt producers, but only 236 of them produce iodized salt. There is no guarantee that locally produce salt is fortified with iodine. The same condition is also occurred in India (Kotwal, 2010) and Haiti (Pilliod, 2003). In Ngargoyoso sub-district, household iodized salt consumption was only 61% (Dewi, 2010) and 12.6% salt in the local market contained iodine less than 30 ppm (Dewi, 2010).

The target of universal salt iodization (USI) in Indonesia has been set up at >90% of household consumed iodized salt (Department of Health, 2000). To make thing worst, since 2009 the GoI stopped producing iodized oil capsule, Yodiol™ (PT Kimia Farma, Indonesia) for its IDD eradication program. This policy was launched following the publication of WHO Global Database (Andersson et al, 2011), where based on Urinary Iodine Excretion (UIE) data, Indonesia has been classified as "more than sufficient". This centralized policy has been argued. Analysis by Atmarita in 2005 showed that one third of the district in Indonesia worsened in term of their prevalence of TGR. Our data from Ngargoyoso sub-district revealed a substantial increase in the prevalence of TGR from 17.1% (1998) to 51.9% (2010) after discontinuation of iodized oil capsule (Dewi, 2016). A "crash program" implemented by adding iodine into drinking water dramatically reduced the TGR (Dewi, 2016).

Indonesia is the biggest archipelago in the world. It consists of 17,000 islands. It is difficult to reach all people in the whole country, especially who are living in remote area. Decentralization decree launched in 2004 opened the possibilities to decentralize IDD eradication program to district administration, including its budget allocation. Local condition in a particular district, or sub-district should be considered. If a public health program to be successful and sustainable, one should do a concerted action. Iodine supplementation alone as showed in the equation above would not achieved iodine sufficiency permanently in a given area. In Ngargoyoso sub-district nutrition education and health sanitation would minimize *E. coli* infection and worm infestations, improve cooking practices and diversify meal plan. The ultimate consequence of IDD is economic stagnation (Dugassa & Negassa, 2012) and result in poverty in the population affected. In turn, poverty will hinder efforts to eradicate iodine deficiency. For instance, it would be difficult to persuade people to eat marine fish - which is high iodine content – because it is more expensive than vegetables locally grown in the sub-district.

There is a discrepancy of data on iodine deficiency in Indonesia. Although there is an increase of TGR from 9.8% in 1998 to 11.1% in 2003 (Andersson et al, 2011), the UIE nationally has already achieved sufficiency (200-299 µg/L) (Andersson et al, 2011) and the latest basic health survey in Indonesia released in 2013 showed the median UIE in school children was 215 µg/L (Department of Health, 2013) It seems that these nation-wide data were used to execute the GoI policy in combating iodine deficiency in Indonesia i.e. universal salt iodization (USI), and withdrawal of iodized oil capsule. However, UNICEF in 2006 make a list of countries with high priority for IDD control (Zimmermann, 2007) and Indonesia was listed at number 3 after Russia and Ukraine. The criteria for selecting countries including: a high number of unprotected infants; an IDD/USI program that is not progressing and the presence of major regional salt producer in the country.

Lesson learned from other countries showed that there is time lag before USI making an effect (Dugassa & Negassa, 2012), and rapid relapse when the supply of iodized salt disrupted (Zimmermann et al, 2004), even failed to show an effect because of other concurrent micronutrient deficiency (Mohammed et al, 2009). In Ngargoyoso sub-district anemia among school children is very common (Dewi et al, 2013).

It is clear from the above discussion that many factors influence iodine deficiency in Ngargoyoso sub-district. Some factors cannot be changed, but others are modifiable. Efforts should be carried out to change these conditions rather than iodine supplementation alone. Now, we can revise the above equation with the new one:

Iodine deficiency + Iodine supplementation + Public health measures = Iodine sufficiency.

LIMITATIONS OF THE STUDY

Since ecological factors are specific to a particular area, it is not possible to make generalization to be used in other places. Some ecological factors also cannot be changed, consequently, IDD elimination program should be tailored accordingly.

CONCLUSION

Ecological perspective provides a new paradigm in combating iodine deficiency in the study area. This holistic approach is relevant to plan IDD eradication program for a big country like Indonesia.

LIST OF ABBREVIATION

GoI Government of Indonesia
ID Iodine Deficiency
IDD Iodine Deficiency Disorders
SNI Standar Nasional Indonesia
TGR Total Goiter Rate
UIE Urinary Iodine Excretion
USD United States Dollar
USI Universal Salt Iodization
WHO World Health Organization

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