
PUBLIC HEALTH RESEARCH

Iodine Deficiency Disorder and Goitre among School Children in Sarawak -A Nationwide Study

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ABSTRACT

Received	20 September 2013
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Introduction	Iodine deficiency disorders (IDD), is one of the most important micronutrient deficiencies which has multiple adverse effects on growth and development. The aim of this study was to determine the prevalence of IDD among school children and to elucidate the distribution of iodized salt at household level in Sarawak, East Malaysia.
Methods	This cross-sectional study was conducted among school children aged 8 to 10 years in 2008. A multi-stage probability proportionate to population size (PPS) cluster sampling method was used to obtain a representative state sample of 1200 school children. Spot urine samples were collected for the determination of urinary iodine concentration while the iodine content in salt was determined using field rapid test kits. The thyroid status was determined by palpation.
Results	Response rate was 92.0% (n=1104/1200). The prevalence of goitre among school children in Sarawak was 2.9% (5.2% in urban, 0.7% in rural). The median urinary iodine concentration (UIC) among the school children was 102.1 µg/L (IQR, 62.3-146.5 µg/L). Urban children had significantly higher median UIC of 109.3 µg/L (IQR, 72.4-159.0 µg/L) than their rural counterparts [91.9 µg/L (IQR, 55.7-140.2 µg/L)]. The salt samples tested by rapid test kit (RTK) showed only 46.0% of household salt contained iodine.
Conclusions	The present study revealed that the population in Sarawak were of borderline iodine sufficient with mild IDD seen in rural areas. Hence, the state IDD control programmes need to encourage and advocate the consumption of iodized salt in order to eliminate IDD-related health problems in Sarawak.
Keywords	Iodine deficiency disorders - goitre - median urinary iodine concentration-iodized salt - Sarawak.

INTRODUCTION

Iodine deficiency disorders (IDD) is caused by the lack of iodine in the diet and the quantity of iodine required by an individual is about 150-200 micro gram per day or a tea spoonful for a lifetime and is required for the production of thyroid hormones, which are essential for normal brain development¹. It is one of the most important micronutrient deficiency disorder which has multiple adverse effects on growth and development in human and most seriously causing damage to the fetus². The consequences of severe iodine deficiency on pregnancy outcome and early infant development have been described and studied extensively³. Moreover, moderate to severe iodine deficiency in children may also cause impaired intellectual function and fine motor skill⁴. There is an increasing evidence that even mild iodine deficiency can cause a significant loss of learning ability⁵.

IDD is a major international public health issue and the current global and regional estimation of the prevalence of IDD showed the status of IDD has improved⁶. However, there are about 31% (1.9 billion) of individuals still have inadequate iodine intake including one-third of all school-age children. The highest prevalence of IDD is observed in Southeast Asia, which accounts for 26% of the global population⁷.

Historically, most of the interior regions of Sarawak have been endemic of IDD. A goitre prevalence of 70 to over 90% had been reported in respondents over 15 year-old, and occasionally cretin had been observed in some villages during the 70s⁸. A number of IDD control activities such as the distribution of iodized salt to pregnant and lactating women attending government clinics, iodization of water supply of schools and long houses located in remote areas have been undertaken to improve situation. Recognising that these activities may not be enough to eliminate IDD in Sarawak, in 1982, the Sarawak State Health Department enacted a legislation designating 16 districts and 3 sub-districts in the state as Goitre Endemic Area (GEA) where only iodized salt can be sold among the population⁹.

In addition, iodine intake of population living in areas with IDD control programmes is monitored at 6 monthly intervals. Apart from small monitoring studies carried out in various areas, there was no wide scale study to assess the prevalence of IDD in Sarawak⁸. In 1997, the Sarawak State Health Department decided to conduct a state-wide study among primary school children aged 8-10 years. This study revealed a goitre prevalence of 0.7% and the median urinary iodine concentration (UIC) was 126 µg/L¹⁰. After more than 10 years of the last state-wide IDD study, the Malaysian Ministry of Health, once again conducted the National IDD Study in 2008.

Using the data from the National IDD (2008), this study aimed to determine the current prevalence of IDD and elucidate the distribution of iodized salt at household level in Sarawak.

METHODS

This was a cross-sectional study conducted from April to July 2008. A multi-stage probability proportionate to population size (PPS) cluster sampling method was used to select a representative sample of 1200 school children aged 8 to 10 year-old in Sarawak. The sampling units were all primary schools in the state registered with the Ministry of Education in 2007. All schools were categorized into 2 groups by locality (urban/rural). Then, a total of 30 schools (15 urban and 15 rural) were selected via systematic random sampling method. For each selected school, 40 students aged 8-10 years were randomly selected and recruited in the study.

Thyroid status was determined by palpation and visual examination by well trained staff nurse. The classification of goitre grading was based on standard criteria, where Grade 0: not palpable or visible; Grade 1: palpable but not visible when the neck was in normal position; and Grade 2: thyroid visible and palpable when neck was in the normal position. The total number of students with Grade 1 and 2 goitre constituted the total goitre rate (TGR). The standard classification range for goitre prevalence were: 5.0-19.9% as mild, 20.0-29.9% as moderate and 30.0% or more as severe⁷.

Spot urine samples were collected from all participated students using urine cups. About 15 ml of urine sample was transferred into a screw cap tube, properly packed and labeled before transporting to the IDD Laboratory in Kota Kinabalu, Sabah for analysis. All urine samples were stored at -20°C until analysis and urinary iodine levels were determined using an in-house modified micro method¹¹. The WHO's criteria for degrees of public health significance for iodine were: 0-19.9 µg/L and 20-49.9 µg/L indicating severe and moderate deficiency, respectively; 50-99.9 µg/L for mildly deficient; 100-199.9 µg/L for optimal; 200 -299.9 µg/L for above requirements; and above 300 µg/L for excessive intake⁷. In addition, median UIC \geq 100 µg/L, indicates elimination of IDD, (with no more than 50% of urine samples $<$ 100 µg/L and no more than 20% of the samples lower than 50 µg/L⁷).

All study respondents were asked to bring to school about 80 gram of salt from their homes in self-sealed plastic bags. The iodine content in salt was determined qualitatively using rapid fields test kits provided by the Institute for Medical Research, Malaysia. The usage of iodized salt at household level were categorised as very poor ($<$ 50%), poor

(50-75%), unsatisfactory (76-90%) and adequate (>90%)¹².

Ethical approval was obtained from the Medical Research Ethic Committee (MREC), Ministry of Health, Malaysia. Approval was also obtained from the Ministry of Education and respective school authorities. Written consent was obtained from the parent/guardian of the involved children prior to the study.

Statistical analyses were carried out using the SPSS software for Windows version 16.0 (SPSS Inc., Chicago, IL). The data was described using count and percentage and were checked for normal distribution. Since data on thyroid size, urinary iodine, and salt were not normally distributed, the differences in median UIC and level of iodine in salt between two groups (urban versus rural) were evaluated using the Mann-Whitney test while differences in the distribution of

thyroid grades, UIC and iodine in salt were evaluated using the Pearson's chi-square test. The significance level was set at $p < 0.05$.

RESULTS

A total of 1104 (92%) respondents participated in the study; 535 in the urban area and 569 in the rural area. The study failed to involve all respondents due to absenteeism.

The prevalence of goitre among school children in Sarawak as assessed by palpation was 2.9%. The overall goitre prevalence was significantly higher in urban than rural respondents (5.2% in urban, 0.7% in rural) and goitre was visible (Grade 2) in only 0.1% of the respondents (Table 1).

Table 1 Distribution of goitre grades among school children in Sarawak

Respondents	Goitre grades Frequency (%)			Total Goitre Rate Frequency (%) (1+2)
	0	1	2	
Urban (n=535)	507(94.8) ^a	27(5.0)	1(0.2)	28(5.2) ^a
Rural (n=569)	565(99.3) ^b	4(0.7)	0(0.0)	4(0.7) ^b
All Groups (n=1104)	1072(97.1)	31(2.8)	1(0.1)	32(2.9)

Chi-square test of goitre prevalence: grade 0 vs Total Goitre Rate, ^{ab}p = 0.001

The median urinary iodine concentration (UIC) among the study respondents was 102.1 µg/L (IQR 62.3-146.5 µg/L); these findings indicated an adequate level of iodine among children in Sarawak. However, the median UIC was significantly lower in rural than urban areas.

The distribution of UIC level ≥ 100 µg/L was found in almost 51% of the study respondents. Mild Iodine deficiency was found in 30% of the respondents, moderate in 15% and severe in about 5% of the respondents. (Table 2).

Table 2 Median and distribution of urinary iodine concentration (µg/L) among school children in Sarawak

Respondents	Median (Interquartile range)	urinary iodine concentration (µg/L) Frequency (%)					
		< 20	20-49	50-99	100-199	200-299	≥ 300
Urban (n=535)	109.3 ^a (72.4-159.0)	18 (3.4) ^c	67 (12.5) ^c	151 (28.2) ^c	237 (44.3) ^c	36 (6.7) ^c	26 (4.9) ^c
Rural (n=569)	91.9 ^b (55.7-140.2)	32 (5.6) ^d	95 (16.7) ^d	181 (31.8) ^d	218 (38.3) ^d	24 (4.2) ^d	19 (3.3) ^d
All Groups (n=1104)	102.1 (62.3-146.5)	50 (4.5)	162 (14.7)	332 (30.1)	455 (41.2)	60 (5.4)	45 (4.1)

Mann-Whitney test of median UIC, :urban vs rural, ^{ab}p= 0.001

Chi-square test of distribution of UIC, :urban vs rural, ^{cd}p= 0.012

The availability of iodized salt at household level was very poor. Of the 1104 salt samples tested by rapid test kit (RTK), less than 50% of them (46%, n=505) contained iodine. In the

urban areas, 45% (n=239) of households salt contained iodine compared to 47% (n=266) in rural areas, however, the differences was not significant (Table 3).

Table 3 Distribution of iodized salts among households in Sarawak

Salt samples	Iodine content in salt Frequency (%)	
	Yes	No
Urban (n=535)	239 (44.7) ^a	296 (55.3) ^a
Rural (n=569)	266 (46.7) ^b	303 (53.3) ^b
All Groups (n=1104)	505 (45.7)	599 (54.3)

Chi-square test of distribution of iodine in salts: urban vs rural, ^{ab}p=0.49

DISCUSSION

Iodine deficiency disorders (IDD) studies are usually carried out in schools as school-age children are appropriate target group for IDD surveillance and evaluation of IDD control programmes due to high vulnerability and easy accessibility to a variety of surveillance activities¹³. The prevalence of goitre gives an idea of the past history of iodine intake while the urinary iodine concentration (UIC) is the most practical biochemical marker for the evaluation of the current iodine supply at population level¹⁴.

Based on goitre and UIC criteria for severity of IDD⁷, the goitre prevalence of 3% among the study respondents can be classified as of normal level, and it indicates that the iodine deficiency among the population has been corrected over time. These findings resembled those of a small study which reported a goitre prevalence of 0.5% in school children¹⁵. And, it also comparable with previous state-wide study which documented a very low goitre prevalence of 0.7%¹⁶. This was a positive finding, as historically, most of the regions in Sarawak have been endemic for IDD^{8,9}. This is probably due to rapid socio-economic development and urbanization rate over the past 20 years which has led to the development of new townships, new businesses, easy accessibility to a variety of restaurants including seafood and improved public transportation system.

The result indicated that the goitre prevalence is higher in urban than rural respondents. However, interpretation of the findings must be made with caution as the palpation method is known to have low specificity. Moreover, a slight increase in thyroid size could not be detected by palpation^{17,18}. Therefore, ultrasound examination should be considered in future IDD study to demonstrate IDD elimination based on goitre criterion, and to be validated with other more easily obtained indicators, such as UIC⁷. Though the median UIC of the respondents was 102 µg/L, 49% of them had UIC <100 µg/L and 19% had <50 µg/L. These findings suggested that the population in Sarawak is of borderline iodine-sufficient, and it was comparable with the

previous state-wide IDD study which reported a median UIC of 126 µg/L¹⁶ and a recent Nationwide IDD Study which reported a median UIC of 109 µg/L in school children¹⁹. In contrast, the rural respondents was found to have a median UIC of 92 µg/L and this indicated that the rural population is still suffer from mild IDD. More than half of them (54%) had biochemical deficiency of UIC <100 µg/L and 22% of them had UIC levels of less than 50 µg/L, which indicated that these population is of borderline iodine-sufficient level. This might be due to the fact that younger respondents are more likely to consume less iodized salt, as part of family diet. A common phenomenon of excessive intake of cassava and goitrogen-containing plants might be another plausible reason as previous study had shown this dietary habit among the rural population in Sarawak^{19,20}. However, this needs to be investigated in future study. The consequences of mild IDD in children can still affect the development of brain²⁰. Children with UIC less than 50µg/L are at risk of developing hypothyroidism, mental and physical retardation if iodine deficiency is not corrected^{22,23}.

Law on prohibited sale of non-iodized salt in most part of rural areas in Sarawak (known as Goitre Endemic Areas) was enacted in 1982 as part of the State government's efforts to improve IDD status in Sarawak⁹. Despite the enactment, the present study showed the percentage of household usage of iodized salt in Sarawak is about 46%. The low availability of iodized salt in both rural and urban areas in Sarawak indicated that the partially universal salt iodisation (USI) practice in Sarawak failed to reach the adequate coverage of 90%⁷. In order to improve the iodine status in Sarawak, the Malaysia government has implemented a policy of mandatory USI in Sarawak in July 2008, in relevant to this state-wide study which requires all salt to contain 20-30 mg of iodine/kg¹⁹. More studies are needed to assess the success of this USI in eliminating IDD in Sarawak.

The study had its limitations. First, an inspection of goitre by palpation is one of the limitations in our study. In areas of mild to moderate IDD, the sensitivity and specificity of palpation were poor^{18,24}. Second, there was a

possibility that the salt samples brought by the respondents from home did not represent salt used in the household as no measure was taken to ascertain that the salt samples were not from special purchase or exchanged with other students. However, the main strength of our study was the high response rate and the data obtained represented Sarawak school children. In addition, the sampling frame was population-based and involved a random sampling of study respondents which can be generalized to the Sarawak population.

CONCLUSIONS

The present study revealed that the population in Sarawak were of borderline iodine-sufficient with mild IDD still existed in rural areas. The introduction of universal salt iodization (USI) in the state will help to eliminate IDD in Sarawak. In order to ensure the success of USI, the state IDD control programmes need to encourage and advocate the consumption of iodized salt. In addition, implementing ban on sale of non-iodized salt and organising awareness campaign for the general population would further enhance the success of the programmes.

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AUTHOR DISCLOSURES

The authors declare that they have no conflicting of interests.

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