PUBLIC HEALTH RESEARCH

Iodine Status after a 3-Year Universal Salt Iodisation in Sarawak, Malaysia

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ABSTRACT

Received 5June 2015
Accepted 28 August 2015

Introduction Following the reveal of borderline iodine sufficiency among the Sarawakians from the 2008 National Iodine Deficiency Disorders (IDDs) survey, a mandatory universal salt iodization (USI) was implemented in Sarawak thereafter. This study aimed to determine the current status of USI in Sarawak after a 3-year implementation of USI from 2008 to 2011.

Methods The IDD survey was conducted between Jun 2011 to July 2011 involving six districts in Sarawak (Sarikei, Mukah, Kapit, Sibu, Bintulu and Miri). The schools were selected via multistage proportionate-to-population size sampling technique and the children were randomly selected via systematic sampling. A total of 19 schools and 661 children were recruited into the survey. Thyroid size was determined by palpation and was and graded according to the classification of the World Health Organization (grade 0-2). The iodine excretion level in spot morning urine was measured using in-house microplate method. The urinary iodine concentration (UIC) values were compared by Kruskal-Wallis test and Chi-square tests were used to compare categorical variables.

Results A total of 610 school children were participated in the study (92.3%). The TGR of grade 1 and 2 was found to be 0.3% (n = 2). Overall the median UIC level was 154.2 (IQR, 92.7 - 229.8) µg/L, with the highest median UIC been observed in Sarikei [178.0 (IQR, 117.6 - 308.9) µg/L], followed by Mukah [174.8 (IQR, 99.0 - 224.3) µg/L)], Miri [158.6 (IQR, 92.3 - 235.4) µg/L], Sibu [147.0 (IQR, 89.8 - 221.4) µg/L], Bintulu [142.3 (IQR, 52.8 - 245.1) µg/L] and Kapit [131.0 (IQR, 88.6 - 201.9) µg/L]. One in every ten child was of iodine deficient (UIC < 50µg/L) while a third of the child (32%) were of adequate level of UIC.

Conclusion The present findings indicate that the mandatory USI successfully improves the iodine level of children in Sarawak. However, regular and proper monitoring of the UIC level in the communities is needed to prevent excessive iodine intake.

Keywords Universal salt iodization - Iodine deficiency disorders - Total goitre rate - Urinary iodine concentration – Sarawak.

INTRODUCTION

Iodine is an essential micronutrient which present in the human body in small amounts and the quantity of iodine required by an individual is about 150 - 200 ug/day.[1] It plays an important role in synthesis of thyroid hormone which is essential for brain and physical development.[2] The main sources of iodine are from the ocean and seafood, including salt water fish, shell fish, kelp, seaweed and seaweed products which can provide a considerable amount of iodine.[3] Terrestrial plants are also a source of iodine depending on the iodine content of the soil in which they were grown.[4] People who do not get sufficient level of iodine from their diet may be at risk for iodine deficiency disorders (IDD).[5] IDD can affect the growth and development of human population from early fetal life to adulthood.[6] The major consequences of iodine deficiency are those related to physical and mental development because they may be irreversible. Hence, the correction of iodine deficiency indicated a major contribution to health and community development.[7]

Salt iodization is an optimum way to ensure sufficient intake of iodine.[8] Implementation of universal salt iodization (USI) can guarantee an adequate and regular intake of iodine since dietary salt intake has been shown to be remarkably constant and falled within a narrow range across populations.[7] The average daily intake of salt is 5-15 g/day for both children and adult. Therefore, the recommended level of salt iodization should be adjusted to provide iodine intake of approximately 150 µg/day by taking into account the climatic factors.[9] Though successful implementation of salt iodization programme may take several years or longer because it involves changes in the salt trade, salt iodization should be considered as the ultimate option for correction of IDD as USI is the most reliable, safe and cost effective way to eliminate IDD.[10]

Most of the interior areas of Sarawak are still prone to IDD owing to the predominantly mountainous terrain and heavy rain. However, advancement in socio-economic development over the last 20 years had given rise to new townships and new businesses which have made outside food including seafood more widely available to the communities living in once remote and inaccessible areas.[11] In 1996, a state survey conducted by the Sarawak State Health Department (SSHD) reported a goitre prevalence of 0.4% among 2524 school children aged 8-10 years; the median urinary iodine concentration (UIC) was 126 µg/L.[12] However, such findings must be interpreted with caution as most of them were from remote areas in which the water iodization programme was implemented in 1995 in rural schools and hostels.[12] Although this water iodizing system offered a new cost effective strategy for the control of endemic IDD in Sarawak, the equipment was prone to breakdown. Thus, this strategy was not applied further.[11]

In 2008, a National IDD survey conducted in Malaysia revealed the median UIC of school children in Sarawak was at borderline-adequate level (101.9 µg/L) and children from rural areas were still having inadequate iodine (median UIC, 96.6 µg/L).[13] Hence, a legislation on universal salt iodization (USI) was enacted in Sarawak in the same year which required all salt for human consumption to be iodized with potassium iodide or iodate, or sodium iodide or iodate and must contain not less than 20 ppm and not more than 30 ppm of iodine.[14] The sale of non-iodized salt was banned and iodine intake of populations living in those areas was monitored annually. The aim of the present study was to determine the current status of IDD in Sarawak after three years of introduction of legislation on USI.

METHODS

This cross-sectional iodine deficiency disorders (IDD) survey was conducted in year 2011 among school children aged 8-10 years attending government primary schools. Sarawak is divided into 11 districts and the study locations were selected after taking into consideration various restraints such as limited resources and logistics feasibility. As a result, six districts (Sarikei, Mukah, Kapit, Sibu, Bintulu and Miri) were selected. In each selected district, three schools were recruited into the IDD survey via multistage proportionate-to-population size sampling technique. Subsequently, about 30-40 children aged 8 to 10 years were randomly selected via systematic sampling from each selected school.[15] A total of 19 schools and 661 school children were enrolled in the survey. General approval was obtained from the Ministry of Education and all school principals prior to the commencement of the survey. The children were excluded from the study if they declined to participate or were absent from the schools on the day of the study.

Enlargement of the thyroid gland in children was assessed by trained nurses and graded according to the classification of the World Health Organization (WHO) as grade 0 (no palpable or visible goitre), grade 1 (an enlarged thyroid that is palpable but not visible when the neck is in the normal position) and grade 2 (a swelling in the neck that is clearly visible when the neck is in a normal position). The total number of school children with grade 1 or 2 constituted the total goitre rate (TGR) of the study population. Severity of IDD was determined based on the TGR values. A TGR of 0% - 4.9% was considered as none, 5.0% - 19.9% as mild, 20.0% - 29.9% as moderate and ≥ 30.0% as severe.[15]

Morning spot urine samples were collected using urine cups from all school children and approximately 15 ml of the urine samples were then transferred into storage tubes. The samples were kept in the container before being transported to the IDD laboratory in Kota Kinabalu. The samples were stored at -18^{o}C until further analysis. Urinary iodine determination was done using an in-house modified microplate method based on manual digestion with ammonium persulfate followed by calorimetric determination of the Sandel-Kolthoff reaction at 405 nm.[16] An UIC of < 20 µg/L was considered as severe iodine deficiency (ID), 20 - 49 µg/L as moderate ID, 50 - 99 µg/L as mild ID, 100 - 199 µg/L as adequate, 200 - 299 µg/L and > 300 µg/L as more than adequate and excessive.[15]

Data analysis was performed using SPSS software version 16.0 (IBM Corp., Armonk, NY, USA). Results were presented in median and interquartile range (IQR) or frequency and percentage. Since the UIC values were not normally distributed, they were compared by Kruskal-Wallis test. Chi-square tests were used to compare categorical variables. *P*-values of less than 0.05 were considered statistically significant.

RESULTS

Overall, 19 schools from six divisions of Sarawak were selected in the study. Three schools were selected from each division except Mukah (n=4). A total of 610 school children were participated in the study, majority of the children were from Sarikei (19.5%), followed by Kapit (18.8%), Mukah (15.7%), Miri (15.7%), Bintulu (15.4%) and Sibu (14.7%). The response rate was 92.3% due to the absence of few school children on the day of the study. More than half of the school children were boys (54.4%) and the rest were girls (45.6%). Approximately two-thirds of them were Iban, followed by Kenyah (11.6%), Melayu (5.1%) and other races (20.3%) The percentage of the school children was almost proportionately distributed across the age groups of 8, 9 and 10 years old.

Table 1 shows the prevalence of goitre among school children in Sarawak. All 610 school children underwent physical examination for the presence of goitre during the survey. The total goitre rate (TGR) of grade 1 and 2 was 0.3% (n=2). The median urinary iodine concentrations (UICs) among school children in Sarawak were shown in Table 2. A total of 610 urine samples were collected in the survey. The overall median UIC was 154.2 (IQR 92.7 - 229.8) µg/L. Of note, the Kruskal-Wallis test revealed statistically significant differences in median UIC amongst the six selected districts ($p < 0.05$). The median UIC was the highest in Sarikei [178.0 (IQR 117 - 308.9) µg/L], followed by Mukah [174.5 (IQR 99.1 - 224.4) µg/L] and Miri [158.6 (IQR 92.4 - 235.4) µg/L]. While school children from Kapit had the lowest median UIC [131.0 (IQR 88.6 - 201.9) µg/L].

Table 1 Prevalence of Goitre amongst school children in Sarawak

Division	Number of schools	n	Goitre Grade (n)			Total goitre rate (1+2)	Severity
			0	1	2		
Sarikei	3	119	119	0	0	0	No
Mukah	4	96	96	0	0	0	No
Kapit	3	115	113	2	0	2	No
Sibu	3	90	90	0	0	0	No
Bintulu	3	94	94	0	0	0	No
Miri	3	96	96	0	0	0	No
Sarawak	19	610	608 (99.7%)	2 (0.3%)	0 (0.0%)	2 (0.3%)	No

Table 2 Median urinary iodine concentration amongst school children in Sarawak

Districts	School	n	urinary iodine concentration (µg/L)	
			Median*	Interquartile range (IQR)
Sarikei	3	119	178.0	117.6 - 308.9
Mukah	4	96	174.5	99.1 - 224.4
Kapit	3	115	131.0	88.6 - 201.9
Sibu	3	90	147.0	89.9 - 221.5
Bintulu	3	94	142.3	52.6 - 245.1
Miri	3	96	158.6	92.4 - 235.4
Sarawak	19	610	154.2	92.7 - 229.8

*Kruskal-Wallis test of median urinary iodine concentration, $p < 0.05$

Table 3 shows the distribution of urinary iodine concentration (UIC) among school children in Sarawak. Out of the 610 urine samples collected, about 40% of them had UIC between 100-199 µg/L (optimal), while more than a quarter of them (28%) had inadequate intake of iodine with UIC of < 100µg/L. On the other hand, approximately one third of them had UIC of ≥ 200 µg/L (more than adequate and excess). Among these school children, more than a quarter of them (27%) who was from Sarikei had UIC of ≥ 300 µg/L compared to only 4% -18% in other districts. Differences of UICs between districts were significant ($p < 0.01$).

Table 3 Proportion of school children by urinary iodine concentration categories and districts

Districts	n	urinary iodine concentration (µg/L) n (%)					
		< 20	20-49	50-99	100-199	200-299	≥300
Sarikei	119	4 (3.4)	4 (3.45)	15 (12.6)	50 (42.0)	14 (11.8)	32 (26.9)
Mukah	96	1 (1.0)	7 (7.3)	16 (16.7)	42 (43.8)	26 (27.1)	4 (4.2)
Kapit	115	3 (2.6)	5 (4.3)	27 (23.5)	48 (41.7)	25 (21.7)	7 (6.1)
Sibu	90	2 (2.2)	11 (12.2)	14 (15.6)	35 (38.9)	16 (17.8)	12 (13.3)
Bintulu	94	5 (5.3)	18 (19.1)	12 (12.8)	30 (31.9)	12 (12.8)	17 (18.1)
Miri	96	1 (1.0)	5 (5.2)	21 (21.9)	37 (38.5)	18 (18.8)	14 (14.6)
Sarawak	610	16 (2.6)	50 (8.2)	105 (17.2)	242 (39.7)	111 (18.2)	86 (14.1)

Chi-Square test of urinary iodine concentration, $p < 0.01$

DISCUSSION

Prevalence of goitre, urinary iodine concentration and thyroid function tests are the three most important indicators recommended by the WHO in iodine deficiency disorders (IDD) surveillance; and researchers are advised to combine at least two indicators, of which one morphological and one laboratory test for IDD surveillance.[17] Hence, the present study assessed the iodine status of school children in Sarawak based on two indicators: i) determination of prevalence of goitre (morphological examination) by TGR, and ii) determination of urinary iodine concentration (laboratory test).

The prevalence of endemic goitre in school children is the most widely accepted marker in evaluating the severity of IDD and the changes in the goitre rate reflect long term iodine nutrition.[15] An area should be classified as endemic for IDD if more than 5% of the school children are suffering from goiter.[15] In the present study, the goitre was 0.3% (n = 2), which indicated that iodine deficiency was no longer a public health problem in Sarawak. The prevalence of goitre was relatively lower compared to 2.9% as reported in the National IDD survey conducted in Sarawak in 2008 (before mandatory USI).[13] The lower prevalence of goitre reported here could be attributed to the availability and consumption of iodized salt at all places in Sarawak since the implementation of mandatory USI from 2008 to 2011. The present findings were in agreement with other international studies whereby the prevalence of goitre decreased remarkably after the introduction of iodized salt programmes.[3, 18, 19, 20] In addition, the thyroid size predictably decreased in response to increase in iodine intake and returned to normal after correction of IDD.[21]

Urinary iodine is the most important biochemical indicator for current state of iodine nutrition because 90% of the ingested iodine is excreted in the urine.[5] A population is defined as free from iodine deficiency with a median UIC level of 100 µg/L and above, i.e. at least 50% of the urine samples had to have UIC of above 100 µg/L and the percentage of sample with UIC < 50 µg/L should not be more than 20%.[15] The median UIC among 610 school children was 154.2 µg/L; and 72% of them had UIC of more than 100 µg/L with only 11% had UIC <50 µg/L.

These findings indicated that these school children were getting adequate dietary iodine. Comparison of median UICs between the present finding (154.2 µg/L) and those from two other previous studies in Sarawak in 1996 (126.0 µg/L)[12] and in 2010 (101.9 µg/L)[13] had demonstrated that there was a mark improvement in median UIC in 2011 among the school children. These results were consistent with other studies measuring urinary iodine in which a mark improvement in iodine nutrition was observed after mandatory USI was implemented.[18,22,23] Although the present findings evidently demonstrated the beneficial of iodized salt in normalizing iodine nutrition among school children in Sarawak, the inaccessibility of certain remote areas which may hinder the delivery of iodized salt could mitigate the effectiveness of the USI particularly among young children who are under school-going age.[24]

Despite the importance of iodine in synthesizing thyroid, over-consumption of iodine with a level of more than adequate (200 - 299 µg/L) or excessive (≥ 300 µg/L) may increase the incidence of autoimmune thyroiditis, hyperthyroidism, subclinical hypothyroidism and goiter.[25,26] Though tolerance to daily high dose-intake of iodine varies between individuals, however, iodine intake of ≥ 300 µg/L/day should be discouraged, particularly in areas where IDD has previously existed.[26] In addition, The United State's Institute of Medicine and European Food Safety Authority suggested that the tolerable upper limit for iodine intake among 7 - 10 years old children should not exceed 300 µg/day.[27] As such, the 27% (Sarikei) and 4 - 18% (other districts) of school children who had UIC of ≥ 300 µg/L may at risk of iodine-induced hyperthyroidism (IIH). The ill-conceived supplementation through iodized salt in Zimbabwe and Eastern Zaire had resulted in a significant number of cases of severe and long lasting IIH.[28] However, a study in China suggested that iodine supplementation may not lead to increase in hyperthyroidism in previously mildly iodine deficient population.[29] Furthermore, the WHO reported that thyroid gland is able to adapt to different doses of iodine and majority of healthy individuals can remarkably tolerant to iodine intake of up to 1 mg/day, which is equivalent to 17 µg/kg body weight.[30]

There were several limitations in this survey which should be considered when interpreting the results. First, the survey sampling frame was not population-based and the present findings could not be inferred to the school children population in Sarawak. Second, palpation of goitre was assessed by different staff nurses and the results may be subjected to misclassification biases. However, the precautions for quality control have been taken by repeated training by expert. Despite these limitations, the major strength of the present survey was that the sampling frame was school-based and by random in order to limit bias. In addition, the response rate was very high (> 90%).

CONCLUSION

After three years of mandatory USI in Sarawak, the iodine intake has improved remarkably among the school children population in Sarawak. The school children in the present study consumed adequate level of iodine from their current diet and this indicated that majority of them had met optimum iodine intake requirement. Since the USI had been shown to reduce the risk of IDD, continuous monitoring of iodized salt quality at all levels are strongly recommended to ensure the sustainability of USI in Sarawak in controlling IDD. In addition, future research on the status of iodine adequacy in other vulnerable groups such as neonates, pregnant and lactating women is warranted.

ACKNOWLEDGEMENT

The authors would like to thank the Director General of Health Malaysia for the permission to publish this study; pupils and teachers for their participations in this survey. This survey was conducted by the Sarawak State Health Department, Ministry of Health Malaysia.

AUTHOR DISCLOSURES

The authors declare that they have no conflicting of interests.

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