Tropical Biomedicine 23(2): 172–178 (2006)

An evaluation of the effectiveness of water iodinator system to supply iodine to selected schools in Terengganu, Malaysia

Lim, K.K.[1], Siti Rohana, D.[2], Zawiah, A.[1] and Wan Nazaimoon, W.M.[1]
[1] Institute for Medical Research, Jalan Pahang, 50588, Kuala Lumpur; Malaysia.
[2] Terengganu State Health Department, Wisma Persekutuan, Jalan Sultan Ismail, 20920, Kuala Terengganu, Terengganu, Malaysia.
Email : limkk@imr.gov.my
Received 2 July 2006; received in revised form 21 August 2006, accepted 23 August 2006.

Abstract. This is a cross-sectional study conducted from January to September 2004 in a group of school children aged 8 -10 years old. The schools and study subjects were selected using stratified systematic sampling technique. A total of 44 schools and 1100 subjects were selected from schools with iodinator and schools without iodinator. Samples collected were spot urine and drinking water. Dietary and iodised water consumption data were obtained from interviews. A total of 931 subjects (84.6%) responded; 558 (50.7%) from schools with iodinator and 373 (33.9%) from schools without iodinator. Results showed that in more than half (53.8%) of the schools with iodinators, mean water iodine level was below 25 µg/L. The study population in Terengganu was found to be mildly iodine deficient with an overall median urine iodine concentration (uIC) of 74 µg/L. Based on WHO criteria, 4.1% with uIC <20 µg/L (severe), 19.5% with uIC between 20-49 µg/L (moderate), 49.2% with uIC between 50-99 µg/L (mild) and 27.2% was iodine sufficient with uIC ≥100 µg/L. Majority of the study subjects were found to have high seafood intake (> 90%) and low in goitrogen food intake. This study suggests water iodinator system may not be a suitable method of supplying iodine and an alternative is needed in order to eradicate the iodine deficiency problem seen in some parts of Malaysia.

INTRODUCTION

Iodine is an essential constituent in the synthesis of the thyroid hormone thyroxine (T_4) and triiodothyronine (T_3). The role of iodine in nutrition arises from the importance of thyroid hormones to growth and mental development (Graeme, 1994). Young children who received inadequate iodine are at risk of sub-optimal mental development and ability to learn (Bleichrodt *et al.*, 1987). Studies on school children living in the iodine deficient areas from several countries by Hetzel (1995) showed impaired school performance and intelligence Quotients (IQs) compared to similar group from non iodine deficient areas. Study by Zimmermann (2006) also showed that Iodine supplementation improved cognitive and motor performance in iodine deficient school children.

In 1995, a survey was carried out in Peninsular Malaysia amongst primary school children aged 8 – 10 years. The survey revealed an overall goitre prevalence of 2.2% but 6.1% were found among rural female children in the states of Kelantan, Kedah, Perlis, Pahang, Perak and Terengganu suggestting mild IDD may still exist in the rural areas (IMR, 1995). As a result, the iodine deficiency disorders (IDD) eradication programme was implemented by the Ministry of Health which include distribution of iodised salt to pregnant and lactating women attending government clinics, iodisation of water supply to schools located in remote areas, and iodisation of the water supply to the aboriginal settlements (IMR, 1999).

In Terengganu, the iodised water supplementation programme has been operating since 1997 following the success achieved with the system in Lubok Antu, Sarawak (Foo et al., 1996). A pilot study was carried out in 2003 to evaluate the effectiveness of the programme. Based on the World Health Organisation (2001) criteria, data showed that despite usage of the iodinator in the school water system, the overall median urine iodine concentration (mUIC) level amongst school children was still below 100 µg/L (IMR, 2003).

Hence, to reaffirm the earlier findings, a more comprehensive survey was carried out to determine the urinary iodine status amongst the school children in Terengganu and to determine factors that may affect the effectiveness of the programme.

MATERIALS AND METHODS

The cross-sectional study was conducted from January to September 2004 in school children aged 8-10 years old in Terengganu. The schools were selected based on the stratified random sampling technique, and were stratified into two categories; schools with iodinator (196) and schools without iodinator (127). Using the systematic sampling technique, 26 schools were selected from schools with iodinator and 18 from schools without iodinator. A total of 1100 subjects (8 -10 y) were studied where 655 subjects were from schools with iodinator and 445 from schools without iodinator. Letter of consent from the parent/guardian of each child involved in the study was obtained prior to the study. The study protocol was approved by the Medical Research Ethic Committee (MREC) of the Ministry of Health, Malaysia.

Spot urine and drinking water samples were collected into test tubes, labelled and packed into polystyrene boxes containing ice, before being transported to the Institute for Medical Research (IMR) for analysis. Samples were kept at -20ºC prior to analysis. Iodine concentration in urine and water was determined by acid digestion method and catalytic reduction of ceric ion by arsenite salt (Dunnet al., 1993). Stanbury & Pinchera (1995) used WHO criteria to classify the urinary iodine concentration; <20 µg/L (severely deficient), 20-49 µg/L (moderately deficient), 50-99 µg/L (mildly deficient) and ≥100 µg/L (adequate). For water, an iodine level of <25 µg/L was considered as inadequate and ≥25 µg/L as adequate (Foo, 2002).

Dietary and iodised water consumption data were obtained using food frequency questionnaire. Food was classified into two groups according to their iodine and goitrogen contents with reference to the standard nutrition textbook and modified from the standardised dietary intake questionnaire (Ministry of Health, 2002). Frequency of consumption was considered high if any of the food was consumed more than once per week and low if the subjects consumed the food less than once per week or 2-3 times per month.

Iodised water was supplied through iodinator, a system comprising of a venturi nozzle and a bypass pipe connected to an upright chamber (diffusion chamber) containing a single silicone sodium iodide elastomer and an interconnecting pipe (suction pipe) linking the bypass to the nozzle. A water enters the inlet pipe and passes through the venturi constriction, a negative pressure is generated and as a result, a portion of the water from the inlet pipe is driven up the bypass pipe. The water passing through the bypass pipe picks up the iodide that has diffused down the chamber (released from the elastomer) and returns to the main water flow (outlet pipe) via the suction pipe and nozzle. The taste of iodised water is similar to normal drinking water.

Statistical analysis was carried out by using the SPSS version 11.5. Differences in mUIC between groups were evaluated using the Mann-Whitney test and Kruskal-Wallis test while the differences between populations in mUIC were evaluated using Pearson's chi-square statistic. Two-tailed p values less than 0.05 were taken as significant.

RESULTS

A total of 169 subjects (15.4%) of the selected school children did not participate in the study either due to failure to obtain parental consent or was absent from school when the study was conducted.

Table 1 shows the median water iodine concentration (mWIC), mean and distribution of iodine concentration in drinking water supply for schools with and without water iodinator system. The mWIC level amongst schools with water iodinator system was 14.00 µg/L and was significantly higher than schools without water iodinator system (p=0.001). Out of the 26 schools with water iodinator system, only 12 (46.2%) had sufficient iodine (≥25 µg/L) in the drinking water supply (schools with functioning water iodinator). For the other 14 (53.8%) schools with iodinator, iodine level in drinking water supply was found to be below 25 µg/L (schools with non-functioning water iodinator). For schools without water iodinator system, water iodine level was all low (<25 µg/L). The comparison in median water iodine concentration (mWIC) and mean concentration of iodine in drinking water supply between schools with functioning and not functioning water iodinator system. The mWIC level amongst schools with functioning water iodinator system (79.5 µg/L) was significantly higher than schools with non-functioning water iodinator system (p=0.001).

Table 2 shows in schools with water iodinator system, the mUIC of 75.00 µg/L was not significantly different from the mUIC of

Table 1. Median, mean and distribution of water iodine concentration (µg/l) in schools with and without water iodinator system in Terengganu

Group	No. of schools (%)	Iodine level in water (µg/l)			
		mWIC	Mean ± SD	iodine insufficient (< 25 µg/L)	iodine sufficient (≥25 µg/L)
Schools					
With water iodinator system	26 (59.1%)	14.0*	75.96 ± 115.1	14 (53.8%)	12 (46.2%)
Without water iodinator system	18 (40.9%)	10.0 *	10.44 ± 1.9	18 (100.0%)	0 (0.0%)
With water iodinator system					
Functioning water iodinator system	12 (46.2%)	79.5**	153.08 ± 135.49		
Not functioning water iodinator system	14 (53.8%)	10.0 **	10.71 ± 1.54		

Mann-Whitney test : *p = 0.001 ; **p = 0.001

Table 2. Median and mean urine iodine concentration (µg/l) for school with and without water iodinator system in Terengganu

Group	No. of schools	n	Urine iodine (µg/l)	
			mUIC	Mean ± SD
With water iodinator system	26	559	75.00*	88.13 ± 63.31
Without water iodinator system	18	372	73.00 *	92.15± 98.54
Total	44	931	74.00	89.74± 79.26

Mann-Whitney test : *p = 0.707

73.0 µg/L obtained for schools without water iodinator system.

The mUIC level amongst the 282 study subjects from schools with functioning water iodinator system was 82.0 µg/l, In schools with not functioning water iodinator system and without water iodinator system, mUIC were 70.0 µg/L and 73.0 µg/L respectively. The mUIC was significantly different between the three groups of schools (p=0.001) but there is no significant difference in the mUIC between the group without water iodinator system and the group with water iodinator system but not functioning (p=0.087) as shown in Table 3.

Table 4 shows 4.1% of the study subjects had urine iodine concentration (uIC) <20 µg/L (severely insufficient), 19.5% had uIC between 20-49 µg/L (moderately insufficient), 49.2% had uICbetween 50-99 µg/L (mildly insufficient) and 27.2% had uIC ≥100 µg/L (sufficient). There was significant difference between the three population in the distribution of uIC (p=0.002). A very significant difference in the mUIC was noticed between the group with functioning water iodinator system and the other two group (p=0.001 and p=0.019). However, no significant difference in the mUIC (p=0.156) between the group without water iodinator

Table 3 : Median and mean urine iodine concentration (¼g/l) in schools with water iodinator system and without water iodinator system in Terengganu.

Group	No. of schools	n	Urine iodine (µg/l)	
			mUIC	Mean ± SD
Functioning water iodinator system	12	282	82.0[a]	97.0 ± 64.7
Not functioning water iodinator system	14	276	70.0[b]	97.0 ± 64.7
Without water iodinator system	18	373	73.0[c]	79.1 ± 60.7
Total	26	931	74.0	89.7 ± 79.3

Kruskal-Wallis test ^{abc}p= 0.001,
Mann-Whitney test : ^{ab}p = 0.001 ; ^{bc}p = 0.087; ^{ac}p = 0.020

Table 4. Distribution of urinary iodine concentration (µg/L) based on World Health Organisation (WHO) criteria

Group	No. of schools	n	urinary iodine concentration (µg/l)			
			<20 µg/L (severe)	20-49 µg/L (moderate)	50-99 µg/L (mild)	≥100 µg/L (sufficient)
Functioning water iodinator system	12	282	6 (2.1%)[d]	53 (18.8%)[d]	124 (44.0%)[d]	99(35.1%)[d]
Not functioning water iodinator system	14	276	18 (6.5%)[e]	62 (22.5%)[e]	135 (48.9%)[e]	61 (22.1%)[e]
Without water iodinator system	18	373	14 (3.8%)[f]	67 (18.0%)[f]	199 (53.0%)[f]	93 (24.9%)[f]
Total	44	931	38 (4.1%)	182 (19.5%)	458 (49.2%)	253 (27.2%)

Chi-square test ^{def}p = 0.002; ^{de}p = 0.001; ^{ef}p = 0.156; ^{df}p = 0.019

system and the group with water iodinator system but not functioning.

The consumption of drinking water from school water supply, seafood intake and goitrogen food intake amongst the subjects are shown in Table 5. For schools with water iodinator system, only 243 (43.5%) of the study subjects under this programme were found to drink iodised water more than once a week from the iodinator system. The frequency of seafood intake such as fish, prawns and cuttlefish in the two groups of subjects were consumed more than once per week by more than 90% of the subjects. However the frequency of goitrogen food intake in the study subjects are lower compared to seafood intake, only less than 35% of the subjects consumed goitrogen food more than once per week.

DISCUSSION

This study has shown that the median water iodine concentration (mWIC) was significantly higher in schools with water iodinator system compare to school without iodinator system. This indicates that overall, the iodine deficiency disorder (IDD) programme in Terengganu did improve the iodine content in the schools water system. However the concentration is still below the desired optimal level. This study also shows that the water iodisation programme in Terengganu has failed to achieve the national objectives of IDD. More than half (53.8%) of the iodinators installed in schools in Terengganu had water iodine level below 25 µg/L. This is based on the minimum level of iodine detected (25 µg/L) by the water rapid field test kit in the water collected from the water pipes with iodinators (Foo, 2002).

The study also found that there were several iodinators which were nonfunctional; comparison between those iodinator that is functioning (79.5 µg/L) and not functioning (10.0 µg/L) shows a very significant difference in the mWIC level (p=0.001). Based on the result of mean urine iodine concentration (mUIC) of 74.0 µg/L, the study population in Terengganu could be classified as mild IDD (Cuthberton et al., 2000). The results were consistent with the pilot study done in Terengganu in 2003 where the mUIC was 68.2 µg/L (Lim et al., 2003). Despite the usage of iodinator in the school water system, the overall mUIC level amongst the children was still below 100 µg/L. Further in-depth study is therefore needed to find the cause of this failure.

With good maintenance and monitoring programme (Foo et al., 1996; Benmiloud, 1997). Water iodinator system should improve the IDD problem as shown by the results of Table 4 and Table 5, as the study subjects' mUIC in school with functioning water iodinator system were significantly higher than school without functioning water iodinator system (functionality of the water iodinator system) (p=0.001 and p=0.002). Consumption of the iodised water supplied in the schools was found to be very low, less

Table 5. The frequency of water consumption, seafood intake and goitrogen food intake of study subjects in schools with and without water iodinator system

Group	n	frequency of water consumption		frequency of seafood intake		frequency of goitrogen food intake	
		High	Low	High	Low	High	Low
With water iodinator system	559	243 (43.5%)	316 (56.5%)	530 (94.8%)	29 (5.2%)	530 (94.8%)	29 (5.2%)
Without water iodinator system	372	18 (4.8%)	354 (95.2%)	354 (95.2%)	18 (4.8%)	354 (95.2%)	18 (4.8%)

High = more than once per week
Low = less than once per week or 2-3 times per month.

that half (43.5%) of the study subjects consumed more than once a week. This could also be one of the reasons for the failure of this programme in Terengganu despite the 5-year old water iodisation programme. Based on our approach, majority of the study subjects were found to have high seafood (> 90%) and low goitrogen intake warrant further investigation.

In conclusion, despite relying only on a single spot urine method of collection for urinary iodine and the questionnaires used to collect data for iodised water, seafood and goitrogen food intake, this study has clearly showed that the water iodinator programme implemented in Terengganu schools has failed to achieve its objective of providing sufficient iodine to its target group. Therefore, it is recommended that this system be reviewed and consideration should be given to find an alternative effective method of iodine supplementation, such as using iodised salt (WHO/UNICEF/ICCIDD, 1994; WHO, 1994). Iodine supplementation using iodised salt is relatively cheaper and easily implemented.

Nevertheless, this study has also highlighted the low iodine content in the water system in this country. This indicates that the IDD problem in Peninsular Malaysia may be more widespread than what was previously thought. There is a need to reevaluate the national IDD status in Malaysia. The use of water iodinator depends heavily not only on good maintenance and monitoring but also on community participation and awareness. Perhaps a more rigorous campaign to promote the regular consumption of iodised water and a more strict, regulated maintenance of iodinator by the health department can improve the iodine deficiency eradication programme in Malaysia. All these factors will contribute to higher operational and human resources, costs and staff competency, salt iodisation programme may be a good alternative.

Acknowledgments. This study was a collaborative project between the Nutrition Unit, Institute for Medical Research (IMR) and the Terengganu State Health Department. The study was funded by Ministry of Health funding (MRG-2003-11). The authors wish to acknowledge the excellent technical assistance of Siow Lee Kian, Siti Zuraida Zainol, Zulkafli Hamzah and Young Swee Ing. The authors would also like to thank the Director of Institute for Medical Research (IMR) for permission to publish the data and to the Terengganu State Education Department for their cooperation in the study and all persons who participated in the studies, including school students, teachers health workers and all staff of Nutrition Unit, IMR. Special thanks is also due to Mr. Ooi Poh Keong of Ministry of Health for his views on this study.

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