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Original Article

Iodine deficiency status and iodised salt consumption in Malaysia: findings from a national iodine deficiency disorders survey

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A nationwide cross-sectional school-based survey was undertaken among children aged 8-10 years old to determine the current iodine deficiency status in the country. Determination of urinary iodine (UI) and palpation of the thyroid gland were carried out among 18,012 and 18,078 children respectively while iodine test of the salt samples was done using Rapid Test Kits and the iodometric method. The results showed that based on WHO/ ICCIDD/UNICEF criteria, the national median UI was 109 μg/L [25^{th}, 75^{th} percentile (67, 166)] showing borderline adequacy. The overall national prevalence of iodine deficiency disorders (IDD) with UI<100 μg/L was 48.2% (95% CI: 46.0, 50.4), higher among children residing in rural areas than in urban areas. The highest prevalence of UI<100 μg/L was noted among the aborigines [(81.4% (95% CI: 75.1, 86.4)]. The national total goitre rate (grade 1 and grade 2 goitre) was 2.1%. Of 17,888 salt samples brought by the school children, 28.2% (95% CI: 26.4, 30.2) were found to have iodine content. However, the overall proportion of the households in Malaysia using adequately iodised salt as recommended by Malaysian Food Act 1983 of 20-30 ppm was only 6.8% (95% CI: 5.1, 9.0). In conclusion, although a goitre endemic was not present in Malaysia, almost half of the states in Peninsular Malaysia still have large proportion of UI level <100 μg/L and warrant immediate action. The findings of this survey suggest that there is a need for review on the current approach of the national IDD prevention and control programme.

Key Words: iodine deficiency, urinary iodine, iodised salt, school children, Malaysia

INTRODUCTION

Iodine deficiency is the world's leading cause of preventable mental impairment and its deficiency continues to be a major public health problem.[1] It has been shown that children born to iodine-deficient mothers although may appear to be normal, have lower intelligent quotient (IQ) points, affecting their ability to develop to their full potential and have difficulty learning in school.[2]

Studies have shown that endemic goitre is prevalent in this country especially among the Aborigines or Orang Asli in remote inland areas, the natives of Sabah and Sarawak in Borneo and the Malays in inland areas. The National Iodine Deficiency Disorders (IDD) survey carried out in 1996 showed that IDD was not a public health problem in Peninsular Malaysia.[3] However, there have been contradictory findings reported in subsequent studies and State Health Department IDD monitoring. A study conducted among the Orang Asli women of reproductive age in an urban fringe area in Hulu Langat District, 45 km away from Kuala Lumpur, had recorded goitre prevalence at 32.4%.[4] Meanwhile, the IDD monitoring programme instituted by the Ministry of Health Malaysia showed that the median urinary iodine (UI, in ug/L) in several states such as Perak was 70.5 and Pahang was 90.9.[5,6]

Before the universal salt iodisation (USI) programme was introduced in Sabah in 1999, IDD was a major public health problem with a prevalence of more than 10%.[7] In a state-wide survey conducted in Sabah among 2,122 children aged 8-10 years old, the total goitre rate (TGR) based on ultrasound was 18% with median UI at 65 μg/L. In contrast, a study involving 2,524 school children aged 8-10 years old in Sarawak after the implementation of water iodination showed a lower TGR at 0.7% and a median UI at 126 μg/L.[8]

Various multi-pronged strategies have been implemented to tackle IDD problem in the country. Universal salt iodisation have been implemented in Sabah and the

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majority of the districts in Sarawak since 1999, under the Malaysian Food Act 1983 - Food (Amendment) Regulations 1999, sub-regulation 285.[9] Water iodination was introduced in several states particularly in Sarawak, Kedah, Perak, Kelantan and Terengganu. However, with the exception of Sabah, IDD continued to be unabated. A study conducted by the Institute for Medical Research showed that despite the use of water-iodinator system to supply iodine in 26 schools in the state of Terengganu, the median UI of the school children was only 75 ug/L, not significantly different from the median UI of 73 ug/L in children from schools without the iodinator.[10] As shown in many countries such as China, Tibet and Bhutan, USI seemed to be the most effective method to eliminate iodine deficiency.[11] In this respect, there may be a need to institute USI for the whole of Malaysia. Therefore, a national survey was conducted among school children aged 8-10 years old to determine the status of IDD and consumption of iodised salt among the households in the country.

MATERIALS AND METHODS

This study was s a cross-sectional survey with a complex survey design. The target population were school children aged 8-10 years old attending primary schools in the country. They were selected because of easy recruitment and were representative of different socio-economic classes; since in Malaysia, almost all children of this age group attended school. In addition, their thyroids can reflect fairly recent effects of iodine nutrition.[12]

In general, Malaysia is divided into two major geographical locations, Peninsular Malaysia and East Malaysia. Peninsular Malaysia consists of eleven states and two Federal Territories whereas East Malaysia which is located in the Borneo Island comprises of two states (Sabah and Sarawak) and one Federal Territory. The sampling units for the survey were all the primary schools in the eleven states and three Federal Territories in Malaysia, registered with the Ministry of Education. The schools were first divided into urban and rural areas based on the current classification used by the Ministry of Education. A total of 30 schools (15 urban and 15 rural) were then randomly selected from each state. The sample size was calculated based on 95% confidence interval (CI), relative precision of 5%, design effect of 2, non-respondent rate of 20%.The anticipated prevalence for the country was 20%, which based on the lowest prevalence reported in 2005 for Sabah following 5 years of USI gazettment.[13] About 1,200 school children were randomly selected from the school roll from each state. The study was approved by the Medical Research and Ethics Committee, Ministry of Health Malaysia. Written informed consents were obtained from their parents or guardians prior to the study.

Data collections were carried out from March to June 2008 by trained school health teams, led by field supervisors in all the respective states. Students were interviewed using a structured pre-tested questionnaire which consisted of both open and close-ended questions that covered the socio-demographic characteristics such as age and ethnicity. The ethnicity of the respondent was determined based on the ethnicity of the father. In our study, IDD gazetted area was defined according to the Malaysian Food Act 1983 and Food Regulations 1985.[9] During the data collection period, Sabah and the majority of the districts in Sarawak had been gazetted under the Food Act 1983.[9]

Urinary iodine

Spot urine specimens were collected using urine cups from all study subjects irrespective of their thyroid status. About 15 ml of the urine sample was then transferred into a storage tube, sealed tightly with screw top before being transported to the assigned laboratory, at the Institute for Medical Research, Kuala Lumpur or one of the three Public Health Laboratories (Sungai Buloh, Ipoh and Kota Kinabalu). Urinary iodine level was determined by an in-house modified micro-method established by the Institute for Medical Research.[14] Whenever a reading was above the highest reference standard, the sample was reanalyzed in dilutions. Assay performance was monitored stringently using internal quality controls established in each participating laboratory and all laboratories were also required to participate in an external quality assurance programme conducted by the International Resource Laboratories for Iodine Network-Australia. The epidemiological criteria for assessing iodine nutrition using median UI concentration in school-age children was based on WHO/ICCIDD/UNICEF, 2007 recommendations.[12]

Thyroid size status

The subjects were examined by trained research staff for goitre grade using the procedure as recommended by the ICCIDD/ UNICEF/WHO.[11] Simplified classification of goitre was used: Grade 0: no palpable or visible goitre; Grade 1: a goitre that was palpable but not visible when the neck was in the normal position; and Grade 2- a swelling in the neck that was clearly visible when the neck was in the normal position and was consistent with an enlarged thyroid when the neck was palpated.

Assessment of the severity of IDD was based on the TGR, which was the sum of grades 1 and 2. The TGR values used for the determination of IDD severity were as follows: 5.0-19.9% as mild, 20.0-29.9% as moderate and 30% or more as severe.

Iodine determination in salt

All the school children were asked to bring approximately 80 gram of salt from their respective homes or family kitchens in self-sealing polythene bags. The presence of iodine in salt was then tested using Rapid Test Kits for iodate and iodide produced by the Institute for Medical Research, Malaysia. From the total number of salt samples brought by the children in each school, 10% were randomly selected for iodine level determination using iodometric titration method.[15]

Data management and analysis

Centralized data entry and data cleaning were carried out using a web-based system that allowed for simultaneous multiple data entry. As a control measure, the same data was entered twice by two different teams. Verification and consistency of the data entered were then checked by the Principal Investigator.

Data management and analysis were done using SPSS (Statistical Package for Service Solutions) for Windows version 15.1 with Module for complex sample analysis.[16] Adjusted weights were employed to provide the estimated population. The current study population was weighted against the National Statistic, Ministry of Education reported in June 2007. The findings of the study were reported as the weighted estimates after taking into account the complex survey design and non-proportionate number of school and school children involved in the study from each school and state. In this respect, a weighing factor was used to account for sampling design, non-response and post stratification for stratum (urban and rural), sex, age group and ethnicity. Since the distributions of iodine level in urine were skewed, the data were presented as median and 25th, 75th percentile. Data with normal distribution was presented as means and 95% CI. The difference between two groups is considered to be significant if the lower 95% CI of one group does not overlap with the upper 95% CI of the other group. Chi-square test for complex sample survey data was also carried out to measure the association for the categorical data. The adjusted F is a variant of the second order Rao-Scott adjusted statistic. The significant ($p<0.05$) is based on the adjusted F and its degree of freedom.

RESULTS

A total of 445 primary schools comprising of 18,078 respondents from 250 urban and 195 rural schools had participated in this survey. The overall response rate was 94.2%. The main reason given for non-participation was inability to attend or was absent on the day of the study due to other commitment or was on sick leave. The 18,078 respondents participated in this survey represented a total of 1,491,876 school children aged 8-10 years old in the country. Of that, 10,688 (55.9%) and 7,390 (44.1%) were from urban and rural areas respectively. The distribution of the respondents by sex was slightly higher for boys than girls at 51.4% and 48.6% respectively. The ethnic composition of the respondents consisted of Malays (58.8%), Chinese (17.5%), Indians (9.2%) and others.

Urinary iodine status

From the 18,078 school children aged 8-10 years old who participated in the study, 18,012 urine samples were collected and analysed for UI concentration. This represents 1,487,233 school children of the same age groups in the country. There were 66 children who were unable to give their urine samples despite efforts made to overcome the problems. As shown in Table 1, the overall median UI concentration for Malaysia was 109 µg/L (25th, 75th percentile: 67, 166). The median UI was higher in the IDD gazetted than non-IDD gazetted areas for both urban and rural areas. The overall median UIs according to the age groups, ethnicity, sex, parental occupational groups for rural school children were also lower than their urban counterparts.

Meanwhile, the overall median UI for Peninsular Malaysia was 104 µg/L (25th, 75th percentile: 65, 161). On the other hand, the median UI in a fully gazetted state (Sabah) was within the optimal level and much better than in a partially gazetted state (Sarawak).

By states, iodine deficiency was more marked in six states, namely Kedah, Penang, Perak, Pahang, Terengganu and Kelantan, where median UI, irrespective of locations, ranged between 68 to 88 µg/L. The overall median UI for boys [115 µg/L (25th, 75th percentile: 71, 174)] was slightly higher than girls [102 µg/L (25th, 75th percentile: 63, 158)] in both urban and rural areas. A similar trend was seen in all the states, age groups and ethnicity. By ethnicity, the Aborigines (Orang Asli) children were found to have the lowest median UI at 55 µg/L (25th, 75th percentile: 40, 85).

Table 1. Urinary iodine status among school children based on ICCIDD/WHO/UNICEF criteria

Demographic characteristics	n	Urinary iodine (µg/L)	Proportion of UI at different cut-off points	
		Median (25th, 75th percentile)	<50 µg/L [% (95% CI)]	<100 µg/L [% (95% CI)]
Malaysia	18012	109(67, 166)	16.6(15.3, 18.0)	48.2(46.0, 50.4)
Peninsular Malaysia	14742	104(65,161)	17.0(15.6, 18.5)	50.7(48.2, 53.2)
Sabah (fully gazetted)	1097	150(99, 224)	10.1(6.2, 15.9)	26.0(19.8, 33.4)
Sarawak (partially gazetted)	1102	102(62, 147)	19.6(15.0, 25.1)	48.9(42.2, 55.6)
Located in IDD gazetted area†***				
Gazetted	1475	134(79, 192)	13.7(9.7, 18.9)	34.7(28.4, 41.6)
Non-gazetted	16537	107(66, 163)	17.0(15.7, 18.5)	50.1(47.8, 52.5)
Location†**				
Urban	10641	121(74, 180)	14.5(12.8, 16.5)	44.4(41.0, 47.9)
Rural	7371	94(59, 145)	19.2(17.1, 21.5)	53.0(49.7, 56.2)
Sex†***				
Boys	9383	115(71, 174)	14.9(13.3, 16.6)	45.0(42.6, 47.5)
Girls	8629	102(63, 158)	18.4(16.9, 20.0)	51.5(49.0, 54.0)
Ethnicity†***				
Malay	11762	114(71, 172)	14.7(13.3, 16.2)	47.6(45.0, 50.2)
Chinese	2828	93(56, 146)	20.5(17.8, 23.6)	53.7(48.5, 58.8)
Indian	1200	92(57, 139)	19.6(14.1, 26.5)	53.3(46.1, 60.4)
Aborigines (Orang Asli)	182	55(40, 85)	41.2(34.6, 48.0)	81.4(75.1, 86.4)
Sabah Bumiputera	1059	146(96, 204)	11.1(6.6, 18.1)	26.6(19.9, 34.6)
Sarawak Bumiputera	727	95(57, 145)	23.1(16.8, 30.7)	54.4(45.3, 63.2)
Other Bumiputera	79	132(94, 178)	7.8(3.7, 15.7)	28.0(21.8, 35.2)
Others	175	125(87, 178)	12.9(8.5, 18.6)	31.6(23.0, 41.7)

† Test of independence Pearson Chi-square for categorical data. *$p<0.05$; **$p<0.01$; ***$p<0.001$

Prevalence of IDD based on UI status by demographic characteristics

As indicated in Table 1, the overall national prevalence of IDD (UI <100 μg/L) among school children aged 8-10 years in Malaysia was 48.2% (95% CI: 46.0, 50.4). By severity, 31.6%, 14.2% and 2.4% school children were having mild, moderate and severely iodine deficiency respectively. A higher proportion of school children residing in rural areas had UI below 100 μg/L than their counterparts in urban areas at 53% (95% CI: 50.1, 55.9) and 44.4% (95% CI: 41.2, 47.6) respectively. The prevalence of UI <100 μg/L by status of IDD gazettment had indicated a significantly higher proportion in the non-gazetted IDD areas than in the gazetted areas. The overall national prevalence of UI <100 μg/L was also higher among girls than boys at 51.5% (95% CI: 49.0, 54.0) and 45% (95% CI: 42.6, 47.5) respectively. The same pattern was also observed for the prevalence UI <100 μg/L among school children residing both in urban and rural areas. By ethnicity, the highest prevalence of IDD was recorded among the aborigines (Orang Asli), at 81.4% (95% CI: 75.1, 86.4).

In Peninsular Malaysia, the overall prevalence of IDD among school children with UI <100 μg/L was 50.7% (95% CI: 48.2, 53.2) which was significantly higher than in a fully gazetted state (Sabah) [26.0% (95% CI: 19.8, 33.4)] and was only slightly higher than in a partially gazetted state (Sarawak) [48.9% (42.2, 55.6)]. Of the thirteen states in Peninsular Malaysia, there were six states, namely Kedah, Penang, Perak, Pahang, Kelantan and Terengganu, with IDD prevalence (UI <100 μg/L) of more than 50%.

Thyroid size status

All 18,078 school children participated in the survey underwent clinical examination for the presence of goitre during the school survey. Of these, 51.3% were males and 48.7% were females. As indicated in Table 2, the national TGR was 2.1% (95% CI: 1.7, 2.6), higher in non-gazetted than gazetted IDD areas. Meanwhile, the TGR was slightly higher for Peninsular Malaysia than the overall national prevalence. There was no significant difference between sex or age groups but by ethnicity, the Aborigines in Peninsular Malaysia were found to have the highest prevalence of grade 1 and 2 goitre at 7.9% (95% CI: 4.3, 14.3).

Consumption of iodised salt

From a total of 17,888 salt samples tested for the presence of iodine using Rapid Test Kits, 5,123 samples or 28.2% (95% CI: 26.4, 30.2) were found to contain iodine (Table 3). In IDD gazetted areas, the proportion of households using salt containing iodine was less than 90% and significantly different from the non-gazetted IDD areas at 82.4% (95% CI: 75.2, 87.8) and 20.8% (95% CI: 18.7, 23.1) respectively. The highest proportion of salt containing iodine was noted in WP Labuan at 99.3% (95% CI: 98.6, 99.7), while in Sabah, despite being a fully IDD gazetted state, 96.5% (95% CI: 94.5, 97.8) of the households were consuming iodised salt. Since Sarawak was only partly IDD gazetted, the iodised salt consumption by the households was only 57.0% (95% CI: 49.4, 64.3). The iodised salt consumption among the ethnic groups was highest among the Sabah Bumiputera living in the IDD gazetted areas.

According to the Malaysian Food Act 1983, in IDD gazetted areas, the consumption of iodised salt among the households with iodine levels within 20-30 ppm and more than 30 ppm were 22.5% (95% CI: 15.9, 30.9) and 26.8% (95% CI: 19.6, 35.3) respectively. In Peninsular Malaysia, the proportion of households using adequately iodised salt was very low [2.5% (95% CI: 1.5, 4.1%)]. Despite being

Table 2. Status of thyroid size by palpation of school age children by demographic characteristics

Demographic characteristics	Grade of goitre or thyroid size by palpation			
	Grade 0 (Not palpable or visible goitre)		Grade 1 & Grade 2	
	n	% (95% CI)	n	% (95% CI)
Malaysia	17686	97.9(97.4, 98.3)	392	2.1(1.7, 2.6)
Peninsular Malaysia	14497	97.8(97.2, 98.2)	304	2.2(1.8, 2.8)
Sabah (fully gazetted)	1085	98.9(96.7, 99.7)	12	1.1(0.3, 3.3)
Sarawak (partially gazetted)	1072	97.8(95.3, 99.0)	32	2.2(1.0, 4.7)
Located in IDD Gazetted areas†*				
Gazetted	1461	99.1(97.6, 99.7)	14	0.9(0.3, 2.4)
Non-gazetted	16225	97.7(97.2, 98.2)	378	2.3(1.8, 2.8)
Sex				
Boys	9196	97.8(97.1, 98.3)	208	2.2(1.7, 2.9)
Girls	8490	98.0(97.4, 98.5)	184	2.0(1.5, 2.6)
Location				
Urban	10464	97.9(97.2, 98.4)	224	2.1(1.6, 2.8)
Rural	7222	97.9(97.0, 98.5)	168	2.1(1.5, 3.0)
Ethnicity†*				
Malay	11572	97.7(97.1, 98.3)	248	2.3(1.7, 2.9)
Chinese	2783	98.9(98.0, 99.4)	50	1.1(0.6, 2.0)
Indians	1164	96.8(94.4, 98.1)	37	3.2(1.9, 5.6)
Aborigines (Orang Asli)	166	92.1(85.9, 95.7)	16	7.9(4.3, 14.1)
Sabah Bumiputera	1042	98.8(96.0, 99.7)	18	1.2(0.3, 4.0)
Sarawak Bumiputera	710	98.0(95.3, 99.1)	17	2.0(0.9, 4.7)
Other Bumiputera	75	94.9(85.0, 98.4)	4	5.11.6, 15.0)
Others	174	98.6(94.4, 99.7)	2	1.4(0.3, 5.6)

†Test of independence Pearson Chi-square. *p<0.05; **p<0.01; ***p<0.001

Table 3. Proportion of households using salt containing iodine and proportion of households that consumed adequately iodised salt as determined by the iodometric method, by demographic characteristics

Demographic characteristics	Proportion of households using salt containing iodine as assessed using Rapid Test Kits		Proportion of households that consumed adequately iodised salt at 20-30 ppm as determined by the iodometric method	
	n	% (95% CI)	n	%(95% CI)
Malaysia	5123	28.2(26.4, 30.2)	113	6.8(5.1, 9.0)
Peninsular Malaysia	2477	17.5(15.6, 19.6)	37	2.5(1.5, 4.1)
Sabah (fully gazetted)	994	96.5(94.5, 97.8)	29	24.7(17.1, 34.4)
Sarawak (partially gazetted)	599	57.0(49.4, 64.3)	26	23.4(12.9, 38.6)
Located in IDD gazetted areas†***				
Gazetted	1164	82.4(75.2, 87.8)	36	22.5(15.9, 30.9)
Non-gazetted	3959	20.8(18.7, 23.1)	77	4.5(2.9, 7.0)
Location				
Urban	3396	27.6(24.4, 31.1)	72	5.8(3.9, 8.6)
Rural	1727	29.0(24.9, 33.6)	41	8.0(5.0, 12.5)
Ethnicity †***				
Malay	2573	19.2(17.2, 21.5)	55	3.7(2.4, 5.8)
Chinese	850	31.8(25.4, 39.1)	15	9.2(4.4, 18.2)
Indian	186	16.5(12.3, 21.7)	1	0.5(0.1, 3.4)
Aborigines (Orang Asli)	37	22.0(14.7, 31.6)	2	9.9(1.9, 38.0)
Sabah Bumiputera	959	95.9(93.1, 97.6)	23	23.7(14.7, 35.8)
Sarawak Bumiputera	363	47.8(39.9, 55.7)	14	19.1(9.4, 34.8)
Other Bumiputera	78	99.0(93.2, 99.0)	1	14.7(1.5, 66.3)
Others	77	42.3(22.8, 64.5)	2	6.9(1.4, 28.5)

† Test of independence Pearson Chi-square. *p<0.05; **p<0.01; ***p<0.001

Table 4. Association between household consumption of iodised salt and goitre status with UI status of school children

Household consumption of iodised salt and goitre status	n	UI status (µg/L)			
		<100	100-199	200-299	≥300
		% (95% CI)			
Malaysia: Household consumption of iodised salt†***					
Yes	5110	38.6(35.0, 42.3)	43.1(40.4, 45.8)	9.1(7.8, 10.5)	9.3(7.5, 11.4)
No	12714	52.1(49.9, 54.3)	37.6(36.1, 39.2)	7.1(6.2, 8.1)	3.2(2.6, 3.8)
Sabah (fully gazetted): Household consumption of iodised salt					
Yes	994	26.1(19.3, 34.3)	45.1(38.9, 51.3)	11.5(8.8, 14.9)	17.3(12.4, 23.5)
No	38	25.7(9.9, 52.1)	48.5(32.6, 65.2)	10.4(3.9, 24.8)	15.5(7.7, 28.6)
Sarawak (partially gazetted): Household consumption of iodised salt†*					
Yes	598	43.2(36.8, 49.9)	45.0(39.9, 50.2)	5.2(3.6, 7.4)	6.6(3.5, 12.1)
No	503	56.4(47.0, 65.3)	36.6(29.5, 44.3)	4.0(2.5, 6.4)	3.1(1.6, 5.7)
Malaysia: Goitre status					
Grade 0	17623	48.0(45.8, 50.2)	39.4(38.0,41.0)	7.6(6.8, 8.5)	4.9(4.2, 5.8)
Grade 1 and 2	389	55.5(47.4, 63.3)	32.4(26.4, 39.0)	8.3(4.7, 14.3)	3.8(1.7, 8.2)
Sabah (fully gazetted): Goitre status					
Grade 0	1085	25.8(19.5, 33.4)	46.4(40.2, 52.7)	11.2(8.5, 14.5)	16.6(12.0, 22.5)
Grade 1 and 2	12	46.5(11.7, 85.1)	34.2(13.3, 63.7)	7.2(0.7, 48.0)	12.1(2.0, 48.8)
Sarawak (partially gazetted): Goitre status					
Grade 0	1072	8.7(41.6, 55.8)	41.5(36.1, 47.1)	4.6(3.4, 6.2)	5.2(2.9, 9.0)
Grade 1 and 2	30	59.1(41.5, 74.5)	32.7(19.9, 48.8)	8.2(2.5, 23.6)	0

†Test of independence Pearson Chi-square; *p <0.05; **p<0.01; ***p<0.001

a fully gazetted state, the consumption of iodised salt within the 20-30 ppm level in Sabah was only 24.7% (95% CI: 17.1, 34.4).

Meanwhile, about 50.7% (95% CI: 41.4, 60.1) of salt in IDD gazetted areas (Sabah and some districts in Sarawak) had a iodine level of <20 ppm, where 23.4% had no iodine content. Nevertheless, it was also found that 29.0% (95% CI: 21.2, 38.4) of the iodised salt level consumed by the households in Sabah was more than 30 ppm.

Association between household consumption of iodised salt and goitre grade with UI status

As shown in Table 4, there was a significant association between household consumption of iodised salt and UI status of school children (Chi-square=265.36, Adjusted

F=5.61, df1=1, df2=4, p<0.001). However, there was no significant association between goitre status and UI status of school children in Malaysia, Sabah (a fully gazetted state) and Sarawak (a partially gazetted state).

DISCUSSION

Urinary iodine is a valuable biochemical marker that shows current state of iodine nutrition. It is also used as an indicator for the assessment of IDD because 90% of body iodine is excreted in the urine.[12]

In our survey, the national median UI concentration for Malaysia was 109 µg/L showing borderline adequacy. National median UI for rural school children was less than 100 µg/L, and was lower than their urban counterparts. In Peninsular Malaysia, median UI was 82 µg/L in a 1996 survey as compared to 104.1 µg/L in the current survey. The median UI was higher among urban children than their rural counterparts at 116 µg/L and 92 µg/L respectively. This was comparable to the 1996 survey where median UI was 108 µg/L and 70 µg/L among the urban and rural children respectively.[3] Thus, implying for the last 10 years, the iodine status of Malaysian children based on WHO/ICCIDD/UNICEF criteria, was borderline adequate among the urbanites and mildly inadequate among those living in the rural areas. Thus, this survey has shown that iodine deficiency is not confined only to the remote or interior areas but also occurs in coastal and urban areas, such as Penang.

According to WHO/ICCIDD/UNICEF, the indicator for iodine deficiency elimination is a median UI of more than 100 µg/L, and not more than 20% of the samples should have UI levels below 50 µg/L.[12] In this survey, 48.2% of the school children still had UI <100 µg/L, where the proportion was slightly higher for Peninsular Malaysia at 50.7%, suggesting mild iodine deficiency.

As the only fully gazetted state in Malaysia since year 1999, the median UI level of the school children in Sabah was within the optimal level at 150 µg/L, much higher compared to 65 µg/L in 1996 before USI. Our finding are consistent with the annual State Health Department UI monitoring data since its gazettment.[13] The introduction and implementation of USI in Sabah have helped to eradicate the IDD problem effectively based on a consistent optimum level of median UI since its gazettment in 1999.[13] In many countries, although great progress has been made through widespread introduction of iodised salt, the success of the programme is dependant on the strong and long term commitment from the national government, consumers and salt industries.[12] In IDD-affected areas, cessation of salt iodisation is associated with rapid deterioration of thyroid function in school age children and after five months of discontinuation of salt iodisation, median UI had dropped to 20 µg/L, and after fourteen months, the rate of goitre was similar to the rate before salt iodisation.[17] Therefore, it is crucial to ensure a sustainable IDD control programme that underlines the importance of effective enforcement as children are vulnerable to even short-term lapses in iodised salt.

Although by WHO/UNICEF/ICCIDD recommendation,[12] at least 90% of the households in IDD gazetted areas should be using adequately iodised salt, the findings of this survey showed that only 22.5% (95% CI: 15.9, 30.9) of the households in IDD gazetted areas (Sabah and some parts of Sarawak) consumed iodised salt with iodine level between 20-30 ppm. In a fully gazetted IDD state (Sabah), although more than 90% of the households were using salt containing iodine as tested using Rapid Test Kit, only 24.7% (95% CI: 17.1, 34.4) were using adequately iodised salt with an iodine level of 20-30 ppm.

Whilst correcting iodine deficiency through salt iodisation, one has to be aware that excessive iodine intake may trigger autoimmune thyroiditis and unmasked thyroid disorders such as hyperthyroidism and hypothyroidism in the population. In this survey, the proportion of UI more than 300 µg/L was 16.6% (95% CI: 12.1, 22.2) in Sabah and 19.9% (95% CI: 15.6, 25.1) in Putrajaya. In the case of Sabah, perhaps it was due to the lack of monitoring where about 29.0% (95% CI: 21.2, 38.4) of the salt consumed had an iodine level of more than 30 ppm, which was above the level recommended by the Malaysian Food Act 1983. Tolerance to high doses of iodine could vary among the individuals and many could ingest large amount of several milligrams or more per day without apparent problems.[12] On the other hand, the high median UI of 207 µg/L (25^{th},75^{th} percentile: 154, 268) and high proportion of UI more than 300 µg/L seen in Putrajaya could not be explained. This warrants further investigation, as prolonged excessive iodine may be detrimental to health.

This survey has also highlighted that there is still a fairly large proportion of the population in Sabah, especially in the rural areas, consuming iodised salt but with very low or no iodine. Enforcement of the Malaysian Food Act 1983 needs to be strengthened and more attention be given to improve access to iodised salt and greater awareness with regards to the health benefit of using iodised salt among the rural population. As shown in our survey, there was a significant association between consumption of iodised salt among the households and urinary iodine status. There was a significantly higher number of iodine deficient children residing in households that did not consume iodised salt. There was also a close match between iodine deficiency and goitre status. Our survey had also indicated that there were more children with goitre in the iodine deficient areas. The findings of this survey was consistent with the national survey conducted in Bangladesh in 2004-2005.[18]

Combination of UI and goitre are the most common indicators used to assess iodine status in the population. While UI is a good marker of recent dietary iodine intake, goitre reflects past iodine status.[19] Endemic goitre is defined when the prevalence of goitre is 5% or greater in school children.[12] Thyroid size reflects iodine nutrition over months or years, and changes in goitre prevalence lag behind changes in iodine status.[18] For this reason, goitre can persist among school children even when they have attained iodine sufficiency as indicated by median UI concentration.[12] In this survey, three states were found to record TGR of more than 5%, namely Penang (5.9%), Terengganu (5.7%) and Kedah (5.3%). These findings were consistent with the median UI level of <100 µg/L in these states. Several factors might have contributed to the problem including high intake of food containing goitrogens such as cassava and cabbage. A study conducted by

Osman *et al*. (1992) had found a significant association between the intake of cassava and prevalence of goitre. Individual who consumed cassava more than two to four times per week had four times the risk of developing goitre.[19] In a study on 217 women in an endemic IDD area in western Tanzania, 98% consumed cassava daily and the TGR was found to be 72.8%.[20] Another study conducted among 20 volunteers given boiled cassava shoot for two weeks showed a significant goitrogenic effects on the function of thyroxine hormone and triiodothyronine hormone.[21] Therefore, more investigation is necessary to ascertain the high goitre rate in these states. As a result of USI implementation in Sabah since 1999 by the Ministry of Health to eliminate iodine deficiency, the TGR in Sabah was only 1.1% as compared to 2.1% for the whole country.

In conclusion, the overall median UI for Malaysia was slightly above the WHO/ICCIDD/UNICEF recommended level of 100 μg/L, indicating borderline adequacy of iodine intake in the population. In Peninsular Malaysia, the prevalence of IDD (UI<100 μg/L) was 50.7% (95% CI: 48.3, 53.1). A higher prevalence of IDD was reported in rural areas than urban areas. Although the overall median UI for urban Peninsular Malaysia was within the borderline adequacy, the median UI for rural Peninsular Malaysia was mildly inadequate. The findings of the survey have also shown that, the constraint to sustained elimination in Sabah is the lack of uniform access to iodised salt by the population especially in rural areas. The national TGR was 2.1%. Goitre was not endemic in the country as endemic goitre has been defined as a prevalence of 5% or greater in school children.

Although the overall household's consumption of salt containing iodine in the gazetted areas was 82.4% (95% CI: 75.2, 87.8), the proportion of households using adequately iodised salt according to Malaysian Food Act 1983 of 20-30 ppm was only 22.5% (95% CI: 15.9, 30.9). Although more than 90% of the households in a fully gazetted IDD state (Sabah) consumed salt containing iodine, only 24.7% (95% CI: 17.1, 34.4) had been using adequately iodised salt of 20-30 ppm. Therefore, various multi-pronged strategies need to be undertaken to strengthen the current approach of combating IDD in the country especially in the gazetted IDD areas.

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AUTHOR DISCLOSURES
The authors declare that they have no conflicting of interests.

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Original Article

Iodine deficiency status and iodised salt consumption in Malaysia: findings from a national iodine deficiency disorders survey

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馬來西亞的碘缺乏與加碘塩攝取：全國性的碘缺乏疾病調查

馬來西亞進行全國性的碘缺乏横斷式調查，以學校為基礎，對象為 8-10 歲孩童。測定 18,012 位孩童尿中碘含量，並有 18,078 位孩童經甲狀腺觸診。而塩的含碘量檢測，使用便捷試劑測定和碘滴定法。全体學童尿碘的中位數為 109 µg/L，依據 WHO/ICCIDD/UNICEF 的標準，是位於碘適量的邊緣。整体孩童的碘缺乏疾病(尿碘<100 µg/L)盛行率為 48.2%，其中鄉村的盛行率比市鎮高。原住民的盛行率最高，達 81.4%。全國學童的甲狀腺腫(等級一和二)比率為 2.1%。學校孩童帶來的 17,888 件塩樣本中，有 28.2%含碘。然而在所有家戶中，使用的塩含碘量符合馬來西亞食物法 1983 所建議的(20-30 ppm)戶數比率只有 6.8%。總之，雖然甲狀腺腫未成為馬來西亞的地方性流行病，但馬來半島上將近半數的州，其學童尿碘<100 µg/L 的比例很高，應當立即採取相關行動。本次調查結果建議，有必要檢討目前全國預防甲狀腺腫疾病的措施和控制方案。

關鍵字：碘缺乏、尿碘、加碘塩、學童、馬來西亞