IODINE DEFICIENCY STATUS IN SRI LANKA
2016
FOURTH NATIONAL SURVEY

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Medical Research Institute
In collaboration with UNICEF and World Food Programme
Ministry of Health, Nutrition and Indigenous Medicine

Message from the Secretary - Ministry of Health, Nutrition & Indigenous medicine

The National Iodine Survey for school children (6-12 years) was carried out by the Department of Nutrition of the Medical Research Institute in collaboration with UNICEF and the World Food Programme. This survey was focused on iodine control programme in Sri Lanka.

This is a comprehensive study that should interest not only the medical professionals responsible for the implementation and monitoring of the salt iodization programme but also the salt producers, they have a major role with the iodization process. The findings of this study highlight the need to streamline the salt iodization programme for sustainability.

I highly appreciate the efforts taken by the staff of the Medical Research Institute, for successfully conducting this study. I am grateful to UNICEF & WFP for assisting to uplift the nutrition status of nation and investing on a very important venture of this nature.

Mr. Anura Jayawickrama
Secretary
Ministry of Health, Nutrition and Indigenous Medicine

Message from the Director - Medical Research Institute

The department of Nutrition of Medical Research Institute successfully completed the fourth national iodine survey in 2016. This survey will be useful to identify the current issues regarding the iodine control programme in Sri Lanka.

I highly appreciate the staff of the nutrition department at the Medical Research Institute for their effort and devotion for successfully completing this study. I also would like to extend my gratitude towards UNICEF and World Food Programme for their interest and support to accomplish this study.

I hope this survey will assist to strengthen and monitor the iodine control programme to improve the iodine nutrition status in Sri Lanka.

Dr. L. Kumarathilake
Director
Medical Research Institute

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Last but foremost in mind are the pivotal operators: The Provincial Directors of Health, Regional Directors of Health, Public Health staff, the principals of the schools, teachers, parents and children. To one and all we wish to say we are deeply indebted to you for having been partners in this study.

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Executive Summary

Iodine deficiency has been identified as a problem in Sri Lanka, as early as late 1940s. Since then, several studies have been undertaken at national and sub national levels. Based on the findings from national survey in 1986, it was decided to implement a universal salt iodization (USI) programme. The relevant legislation was adopted in 1995 under the Food Act, 26 of 1980, which specified the mandatory requirement of a minimum level of 50 ppm iodine in salt at factory level and 25ppm at consumer level.

After USI has been implemented in Sri Lanka for a few years, a study was carried out by the MRI in 2000 – 2001 to assess the impact and its effectiveness. The findings indicated that the median urinary iodine levels were optimum (above the cut-off point of 100 μg/L) in all provinces except Uva province in spite of the fact that the proportion of households with intake of adequately iodised salt was inadequate. A wide variation in the iodine content of the different brands of salt available at retail levels were observed, both between brands and within a given brand. Based on these findings, the Ministry of Health revised the gazette notification to regulate salt iodization programme declaring the level of iodine at household level to be maintained at 15 ppm and production level not more than 30 ppm in 2005. Second and third iodine surveys were conducted in 2005 and 2010. In 2010, it was reported that 68 percent of households consumed adequately iodized salt while maintaining the median urinary iodine level at 163.4μg/L.

Salt iodization programme has been implemented for a period of over 20 years and the Ministry of Health has conducted studies on the iodine status of the population every five years as recommended by the global iodine nutrition network. Accordingly, this study was carried out as the fourth national iodine survey, among a sample of school children aged between 6-12 years, in 2016 with the objective of assessing iodine status among such a sample and to determine the adequacy of salt iodization at the level of the manufacturer and determine the iodine levels in the drinking water from different sources.

This study used a cross sectional study design and included several components : school based study among children aged 6-12 years to assess goitre prevalence and urinary iodine levels; assessment of iodine levels in samples of salt collected from the households; estimation of iodine content in drinking water and estimation of iodine content of salt at the level of production.

Calculated sample size for assessment of iodine levels in household salt samples and estimation of urine iodine levels were 900 and 600 school children per province respectively. Thirty clusters (schools) were included from each province. The sample was identified using a multistage stratified cluster sampling technique.Public Health Inspectors (PHIs) of the areas in which the schools were situated were trained as field investigators, by the MRI field survey team visiting each province. In addition to the training in assessment of goitre status, they were trained in procedures in collection of baseline information and in collection of samples of urine.

All school children identified were clinically examined to assess the goitre status and they were requested to bring a sample of salt from their household. Sample of urine for estimating urinary iodine were obtained from 20 children per cluster, selected randomly from each selected class from each cluster in each province. For estimation of iodine content in salt, 30 household salt samples were collected per cluster.For estimation of iodine content in drinking water, field investigators collected three drinking water samples in the locality of the school from all the available sources. Three water samples per cluster were collected for estimation of iodine content in water. External quality controls were performed.

For estimation of iodine content of salt at the level of production, two major salt producers and at least one producer from a district was visited. From each producer the sample of salt was obtained and transported to the MRI laboratory for iodine quantification. Samples were obtained from each type of salt (crystal or powder form).

Among the study population, (total of 8,624), 1.4 percent had Grade 1 goitre and 0.4 percent had Grade 2 goitre, giving a total goitre rate (TGR) of 1.8 percent. Within each province, the total goitre rate (TGR) was higher among females than among males, the highest prevalence being observed among female children was in the North Western province and Sabaragamuwa provinces. The median urinary iodine levels in all provinces were more than100µg/L, with the highest levels in the Northern province (297.3 µg/L) and the lowest in the Uva province (178.8 µg/L). Five out of the 9 provinces did not have any children with values less than 20 µg/L. Of the samples, 29.5 percent had iodine levels above 300 µg/L. The wide variation in the distribution of urinary iodine levels by province was a key observation in this study.

The median iodine content in household salt samples was higher than 15 ppm in all provinces. The lowest median iodine levels were seen in the samples from North Central province (19 ppm) and the highest, in the Central province (26.5 ppm). Of all samples, 74.1 percent had iodine levels within the permitted range, i.e. 15-39.9 ppm. And 4.5 percent of salt samples had iodine values higher than the permitted range (above 30 ppm), this percentage being highest in Central province (11.2 percent) and lowest in North Western province (1.7 percent).

Of the salt samples obtained from the manufacturers, samples from one brand had no iodine at all. Among the other brands, 15 (30.4 percent) had inadequate iodine levels of <15 ppm , 60.8 percentadequate levels of 15 – 39.9 ppm with 7.4 percent having excess iodine (>40 ppm).

The lowest median iodine values in drinking water were observed in samples from the Uva province (8.25 µg/L) and the highest values in samples from the North Central province (75.5 µg/L).

Comparison between the TGR findings of the 2000-01 and 2015/16 surveys shows that TGR has shown a decline indicating an improvement in the iodine nutritional status. In the survey carried out in 2000, the median iodine levels in all provinces and at national level showed ‘ideal’ iodine status. However, in 2015/16, all provinces as well as the national level data indicated more than adequate iodine levels, which is a matter of concern.

1 Introduction

A deficiency of iodine, which is among the body's essential trace elements, is both easy and inexpensive to prevent (WHO 1994)[1]. Deficiency of iodine is associated with several health consequences, grouped as 'Iodine Deficiency Disorders'(IDD).

The first island wide survey to study the problem of iodine deficiency was carried out among the rural population by the Nutrition Department of the Medical Research Institute (MRI) during the years 1947 – 49. Since then several studies have been undertaken by many researchers which indicate the prevalence of goitre in several parts of the island. All these studies indicated that the goitre belt in Sri Lanka was confined to the south-west region of the island extending over the whole of the Western, Sabaragamuwa, Central and Southern provinces and part of Uva province, which constitute the wet zone of the country, with a very high annual rainfall of 100-200 inches. Over 70% of the population of the island reside in this zone [2].

Studies on the prevalence of goitre include the survey carried out in 1986, by Fernando et al (1989)[3] in 17 of 24 districts including 59,158 school children which reported an overall goitre prevalence in the age group 5-18 years of 14.4% (range 6.5% to 30.2%). The goitre rate was higher in rural (21%) versus urban areas (16%), among girls than among boys (23% versus 14%), and in inland (21%) than in coastal (13%) areas. The magnitude of IDD varied by district, from 6.3% in Matale to 30.8% in Kalutara.

National salt iodization programme

On the basis of reported studies that indicated iodine deficiency as an important problem in Sri Lanka, a decision was taken to implement a universal salt iodization programme in 1995. The relevant legislation was adopted in 1995 under the FOOD ACT, 26 of

1. World Health Organization, 1994. Iodine and health eliminating iodine deficiency disorders safely through salt iodisation, WHO/NUT/94.4, Geneva
2. Mahadeva K, Seneviratne DA, Jayatilleke DB, Shanmuganathan SS, Premachandra P and Nagarajah M 1968, Further studies on the problem of goitre in Ceylon, Br. J. Nutr., 22, 527-34.
3. Fernando MA,, S. Balasuriya S,KB Herath, S Katugampola Endemic Goitre in Sri Lanaka Asia Pacific Journal of Publc Health Vol3 1 1989.

1980. This required minimum level of 50ppm iodine in salt at factory level and 25ppm at consumer level. Potassium iodate was designated the sole source of iodine. The sale of non-iodized salt for human consumption was banned to ensure accessibility of iodized salt to each and every consumer.

Under the Section 32 of the Food Act, monitoring of iodized salt is a role of the Department of Health. Public Health Inspectors (PHI) are supposed to monitor the salt at retail and household levels by using simple rapid test kits. The five laboratories in the country carried out the quantitative estimation (titration method) of iodine levels in salt.

After the programme of universal salt iodization had been in existence in Sri Lanka for a few years, a study was carried out by the MRI in 2000 – 2001 to assess the status of the salt iodization programme, especially to study the impact and effectiveness of the programme.

The key findings of the study were: the median urinary iodine levels were above the cut-off point of 100 µg/L in all provinces except Uva, indicating adequate iodine status. In contrast, the total goitre rate in the NCP is among the highest in Sri Lanka, indicating the need for further studies on the mechanism of occurrence of goitre in the NCP[4].

It is interesting to note that the iodine status of 7 provinces was satisfactory in spite of the fact that the proportion of households with intake of salt with adequate levels of iodine was inadequate. Another important observation is the wide variation in the iodine content of the different samples of salt available, both between brands and within a given brand.

As a result, Ministry of Health revised the gazette notification to regulate salt iodization programme, on the 11th August 2005, to reduce the level of iodine at household to 15 ppm and production level not more than 30 ppm. Second and third iodine surveys were conducted in 2005 and 2010. It was reported 91% and 68% of households consumed adequately iodized salt while maintaining the median urinary iodine level at 154.4 µg/L in 2005 and 163.4µg/L in 2010. .

4. Iodine deficiency status of children in Sri Lanka 2000-2001. MRI, Department of Health, UNICEF 2001.

Currently, the salt iodization programme has been implemented for a period of over 20 years. As recommended by the Iodine Global Network, Ministry of Health planned to study iodine status of the population every five years. Hence this study was carried out among a national sample of school children aged between 6-12 years, in 2016.

1.1 General objective

- To assess iodine status among school children aged 6 – 12 years in Sri Lanka

1.2 Specific objectives

- To determine the goiter prevalence rate in children between 6-12 years
- To determine the median urinary iodine levels in school children aged 6-12 years
- To determine the prevalence of households consuming adequately iodized salt (by measuring iodine levels in the salt at household level)
- To determine the adequacy of salt iodization at the level of the manufacturer.
- To determine the iodine levels in the drinking water in different sources

2 Methods

2.1. Study design

This study used a cross sectional study design and included several components.

1. School based study among children aged 6-12 years,
   - a- to assess goitre prevalence
   - b- to assess urinary iodine levels
   - c- to assess iodine levels in samples of salt brought from the households.
2. Estimation of iodine content in drinking water from the sources around the school
3. Estimation of iodine content of salt at the level of production

2.1.1 School based study among children aged 6-12 years

A provincially representative sample of school children aged 6-12 years were identified to be included in the study, to be taken national estimates. This study included the following:

- Selection of subjects and obtaining information on age, sex and other identifying information
- clinical examination for goiter of selected subjects
- estimation of iodine in a sample of urine obtained from the participants
- assessment of iodine content of a sample of salt brought from the household

2.1.1.1. Sample size

Considering the goiter rate among school children aged 6-12 year as 5 percent, the sample size was calculated to give sub national (provincial) estimates on the prevalence of goiter.

Calculated sample size was 900 per province, from each province 30 clusters (schools) were included and 30 participants being selected from each cluster, thus including 8100 students as the sample size for assessment of goiter and household salt iodine assessment (30x30x9). As all children in the selected class had to be included in the study, a total number in the sample exceeded the calculated sample size, which was 8,624.

2.1.1.2. Sampling technique

Multistage stratified cluster sampling technique was used based on WHO guide[5] .

2.1.1.3 Selection of subjects

From a list of schools obtained from the Ministry of Education, all schools having grades 2-7 were identified. As the first stage of sampling, 30 schools were selected from each province, using population proportion to sampling (PPS) technique. For each school, lots were drawn to select the grade in which the study sample was to be identified. In the selected grade, one class was randomly selected for the study from each school.

In the selected class, 30 children were randomly selected from the attendance register for goiter assessment and salt iodine estimation; 15 male and 15 female. Thus, 30 children from each selected class were identified to be included in the study.

A sub sample of 20 children were randomly selected from each cluster for the assessment of urinary iodine levels giving the sample size for urine iodine assessment to be 5400 (20x30x9).

Informed written consent was obtained from the parents through a letter from the principle investigator forwarded through the class teacher. All children who had obtained the consent of their parents and were present on the day of the study were identified as participants. A structured format was developed to obtain identification data, age and sex of children.

a. Clinical examination for goitre

Public Health Inspectors (PHIs) of the area in which the school was situated were trained as field investigators to assess the goitre status of the study group. Grading of goitre was done according to the following system (WHO/UNICEF/ICCIDD 1992).[6]

Grade 0 - Thyroid not palpable not visible,

Grade 1 - Thyroid palpable but not visible with neck in normal position. Moves up wards in the neck as the subject swallows.

Grade 2 - Goitre visible with neck in normal position. Consistent with enlarged thyroid when the neck is palpated.

For quality control purposes, assessment for the prevalence of goiter was carried out by the MRI team in a sub sample of 100 participants in each province (20 from each school

5. World Health Organization 2007, Assessment of iodine deficiency disorders and monitoring their elimination : A guide for programme managers, 3rd edition

6. World Health Organization 1994, Indicators for assessing iodine deficiency disorders and their control through salt iodization, WHO/NUT/94.6, WHO, UNICEF, ICCIDD, Geneva: 1-55.

and total of 5 schools from each province). This sub sample constituted approximately 11 percent of the sample.

b. Measurement of iodine in urine

Sample of urine for estimating urinary iodine were obtained from 20 children, selected randomly from each selected class from each cluster in each province. A total of 600 urine samples was to be collected from each province, giving a sample of 5400.

The following steps were adopted in the collection and transport of urine samples.

- All selected children were made to wash their hands with soap and water under the supervision of the study team.
- Each child was provided with disposable paper-cup with wide mouth and requested them to collect the urine sample, by urinating directly into the cup. They were informed that it will be adequate to provide a sample of urine, to fill half the cup provided.
- Members of the study team wearing disposable gloves, transferred approximately 15 ml of the urine specimen from the cup to a tight fitting screw-capped plastic container. The remaining urine and the cups were disposed appropriately.
- The urine samples were labelled with identification data i.e. province number, school number and the serial number of the child (in that order).
- All 20 samples were stored in the large plastic container and this package was marked with the province number and school identification number and then transported for storage.
- The samples were transported to the Divisional Drug Stores and stored at 4-8^0 C. They were transported to the laboratory of the Nutrition Department of Medical Research Institute (MRI) twice a week with cold packs and stored at -80^0 till taken for analysis. The urine samples were tested on first arrived - first assessed basis. When the test were performed the results were entered into the computer data sheet with the labelling details.

Biochemical technique used to assess urinary iodine levels of the sample was the Ammonium persulfate digestion with spectrophotometric detection of the Sandell-Kolthoff reaction. All samples were analyzed by the trained MLTs at the laboratory at the MRI. Internal quality control was carried out throughout by using pooled samples.

External quality control was carried out in collaboration with the Center of Disease Control (CDC) Laboratory in Atlanta as a partner of the quality control programme (EQUIP).

c. Estimation of iodine content of salt at household level

All children from the selected class from each school were requested to bring a sample of salt from home. Estimation of iodine content in salt was carried out using the titration method. A total of 5516 samples of salt were included in this analysis.

External quality controls were performed using eight unknown samples in different concentrations, made available by Iodine Global Network (IGN) South Asia. An expert in salt iodine analysis from All India Institute of Medical Sciences, New Delhi, India visited MRI and reanalyzed 150 samples (2% of total samples).

d. Knowledge and practices of using iodised salt at household level

Short questionnaire was sent to assess the knowledge and practices of mothers of children with the consent form. Type of salt, the way it is used, storing practices were assessed. With the mandatory salt iodisation programme in the country it was considered that all salt samples available at households were iodised thus avoiding any bias.

2.1.2 Estimation of iodine content in drinking water

The field investigators were instructed to collect three drinking water samples in the locality of the school from different available sources such as taps, well, deep well, tube well, streams etc. Water samples were transported to MRI laboratory using the same procedures adopted for samples of urine. Ninety water samples were supposed to be collected from each province (three water samples per cluster), giving a total of 810 water samples for estimation of iodine content in water.

2.1.3 Estimation of iodine content of salt at the level of production

The Ministry of Health maintains a list of salt producers in the country for licensing purposes. From the list, three categories of salt producers were identified; major, medium and small. A total of 20 salt producers were visited; all major and equal number of medium and small scale salt producers were visited. Visits were made without prior notice. Salt producers were assessed on the knowledge of the technique of iodisation and the iodisation process was observed. From each producer the sample of salt was obtained and transported to the MRI laboratory for iodine quantification. Samples were obtained from each type of salt (crystal or powder form). Information relevant to labelling legislation was obtained; brand name, expiry date, manufacturing date and language etc.

2.2 Data collection at field level

Public Health Inspectors (PHIs) of the areas in which the schools were situated were trained as field investigators, by the MRI field survey team visiting each province. In addition to the training in assessment of goitre status, they were trained in procedures in collection of baseline information and collection of samples of urine.

2.3 Monitoring and supervision of data collection

Monitoring and supervision of data collection was done by Supervising Public Health Inspector (SPHI) of the area, at the school level and SPHI-district, at district level.

Four teams from MRI visiting the provinces carried out overall monitoring and supervision. Each of these teams visited the province and collected data from 5 randomly selected schools from each province.

2.4. Ethical considerations

Ethical clearance was obtained from the ethical committee of Medical Research Institute and permission obtained from the relevant Educational and health authorities. Informed written consent was obtained from parents or guardian of children who attended the study. Confidentiality of information obtained during the study was ensured.

3 Prevalence of Goitre

A total of 8624 children[7] aged 6-12 years from 9 provinces were identified as the study population. Of them, 4256 (49.4 percent) were males and 4368 (50.6 percent) were females (Table 1).

Table 1 : Age and sex distribution of the study population by provinces

Age in years	Male		Female		Total	
	No.	%	No.	%	No.	%
6	319	52.3	291	47.7	610	7.1
7	631	51.6	591	48.4	1222	14.2
8	754	50.8	729	49.2	1483	17.2
9	718	47.2	803	52.8	1521	17.6
10	758	50.6	740	49.4	1498	17.4
11	696	47.8	760	52.2	1456	16.9
12	380	45.6	454	54.4	834	9.7
All	**4256**	**49.4**	**4368**	**50.6**	**8624**	**100.0**

The sample included a marginally higher number of females compared to males.

3.1 Prevalence of goitre by province

A total of 8624 children were included in the study of goitre status. Among this group, 1.5 percent had Grade 1 goitre and 0.4 percent had Grade 2 goitre, giving a total goitre rate (TGR) of 1.8 percent (Table 2)

7. As all children in the selected class had to be included in the study, the total number in the achieved sample exceeded the calculated sample size of 8,100.

Table 2: Prevalence of goitre by province

Province*	Total examined	Prevalence of goitre (%)			Total goitre rate (grade 1+2)	95% Confidence interval
		Grade 0	Grade 1	Grade 2		
Western	913	98.9	1.0	0.1	1.1	0.4-1.8
Southern	961	99.3	0.5	0.2	0.7	0.2-1.2
Central	847	97.5	1.5	0.9	2.5	1.5-3.6
Northern	1009	99.4	0.5	0.1	0.6	0.1-1.1
Eastern	1063	98.4	1.2	0.4	1.6	0.9-2.4
North Western	1062	97.0	2.9	0.1	3.0	2.0-4.0
North Central	927	98.7	1.1	0.2	1.3	0.6-2.0
Uva	897	98.4	1.4	0.1	1.6	0.8-2.4
Sabaragamuwa	945	96.0	2.9	1.2	4.0	2.8-5.2
Sri Lanka	8624	98.2	1.5	0.4	**1.8**	**1.5-2.1**

The total goitre rate varied between provinces ranging from the highest prevalence of 4.0 percent in the Sabaragamuwa province to 0.7 percent in the Southern province. No province had goitre prevalence above the WHO public health cut-off of 5%.

3.2 Prevalence of goitre by sex

Table 3 indicates that within each province, the prevalence of both Grade1 and Grade 2 i.e. total goitre rate was higher among females (2.2 percent) than among males (1.4 percent). The highest total goitre prevalence among female children was in the North Western province and Sabaragamuwa province (4.4 percent). The sex difference in the prevalence of Grade 1 goitre was most marked in the North Western province. The highest prevalence of Grade 2 goitre was seen among the females in the Sabaragamuwa and Central provinces. (0.8 percent).

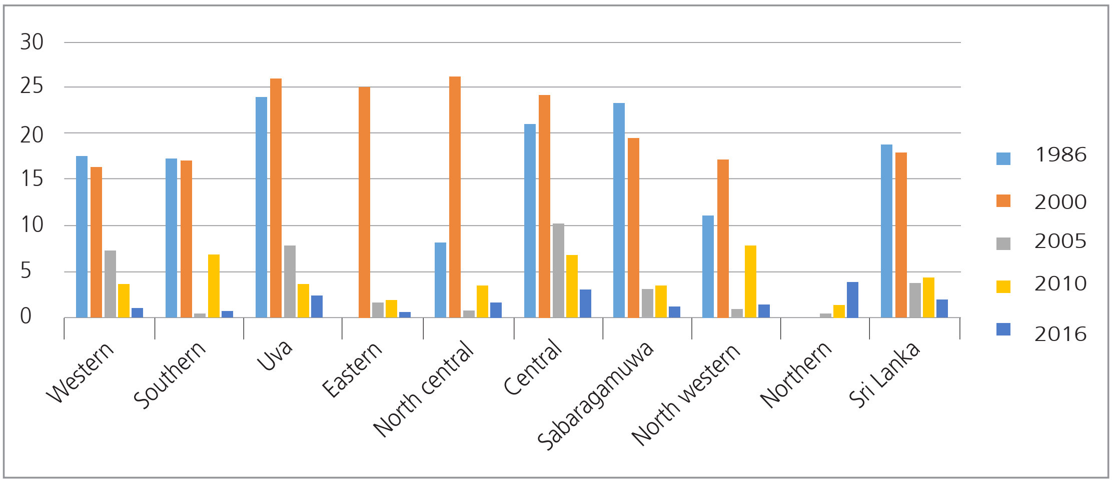
Table 3: Goitre prevalence in children of 6-12 years by sex and provinces

Province*	Total examined		Prevalence of goitre (%) Grade 0		Grade 1		Grade 2		Total goitre rate (grade 1+2) (%)	
	M*	F**	M*	F**	M*	F**	M*	F**	M*	F**
Western	407	506	99.3	98.6	0.7	1.2	0.0	0.2	0.7	1.4
Southern	485	476	99.6	98.9	0.4	0.6	0.0	0.4	0.4	1.1
Central	376	471	97.1	97.9	1.9	1.3	1.1	0.8	2.9	2.1
Northern	513	496	100.0	98.8	0.0	1.0	0.0	0.2	0.0	1.2
Eastern	599	474	98.1	98.7	1.5	0.8	0.3	0.4	1.9	1.3
North Western	522	540	98.5	95.6	1.3	4.4	0.2	0.0	1.5	4.4
North Central	459	468	98.7	98.7	1.3	0.9	0.0	0.4	1.3	1.3
Uva	440	457	99.3	97.6	0.7	2.2	0.0	0.2	0.7	2.4
Sabaragamuwa	465	480	96.3	95.6	2.2	3.5	1.5	0.8	3.7	4.4
Sri Lanka	**4256**	**4368**	**98.6**	**97.8**	**1.1**	**1.8**	**0.3**	**0.4**	**1.4**	**2.2**

(M** = Male children, F** = Female children)

Figure 1 shows the comparison of total goiter rates from 1986 to 2016. It shows the reduction of goiters in all provinces.

Figure 1: Comparison of goitre rates of school children in Provinces from 1986



4 Urine Iodine Levels

4.1 Urinary iodine levels by province

A total of 5000 urine samples were collected from the participants (92.6 percent of the expected sample size). Varied numbers of samples were available from the different provinces (expected sample from each province was 600).

National median urinary iodine concentration was 232.5 μg/L, which is within the optimal range (Table 4). The "optimal" urinary iodine levels are considered to be within the range 100-299 μg/L[8]. The median urinary iodine levels in all provinces were above accepted level of 100μg/L with the highest median urinary iodine levels in the Northern province (297.3 μg/L) and the lowest in the Uva province (178.8 μg/L).

Table 4: The levels of urine iodine by provinces

Province*	Total no. of samples examined	Median urinary iodine concentration (μg/L)	25th -75th percentiles of urinary iodine values (μg/L)
Western	591	233.1	166.7 - 313.3
Southern	608	201.3	121.5 - 289.9
Central	452	220.7	168.3 - 286.4
Northern	562	297.3	230.4 - 355.4
Eastern	564	233.8	159.5 - 323.5
NorthWestern	596	229.4	155.9 - 318.6
NorthCentral	575	278.0	186.3 - 327.2
Uva	501	178.8	126.5 - 259.1
Sabaragamuwa	551	217.5	148.7 - 305.0
Sri Lanka	**5000**	**232.5**	**159.3 - 315.8**

8. Zimmermann MB, Aeberli I, Andersson M, Assey V, Yorg JAJ, Jooste P, et al. Thyroglobulin Is a Sensitive Measure of Both Deficient and Excess Iodine Intakes in Children and Indicates No Adverse Effects on Thyroid Function in the UIC Range of 100–299 μg/L: A UNICEF/ICCIDD Study Group Report. J Clin Endocrinol Metab [Internet]. 2013 Mar 1 [cited 2017 Jul 6];98(3):1271–80. Available from: https://academic.oup.com/jcem/article-lookup/doi/10.1210/jc.2012-3952

4.2 Urinary iodine levels by sex by province

Median urinary iodine levels among males was 241.2 µg/L and was higher than among females, 222.4 µg/L (Figure 2). The lowest urinary iodine values were detected in females in Uva province (190.8 µg/L) and the highest among males in Northern province(302.2 µg/L). It is important to note that in all provinces except Uva province, and females in the Southern province, the median urinary levels in both sexes were above 200 µg/L.

Figure 2: Median urinary iodine levels by province

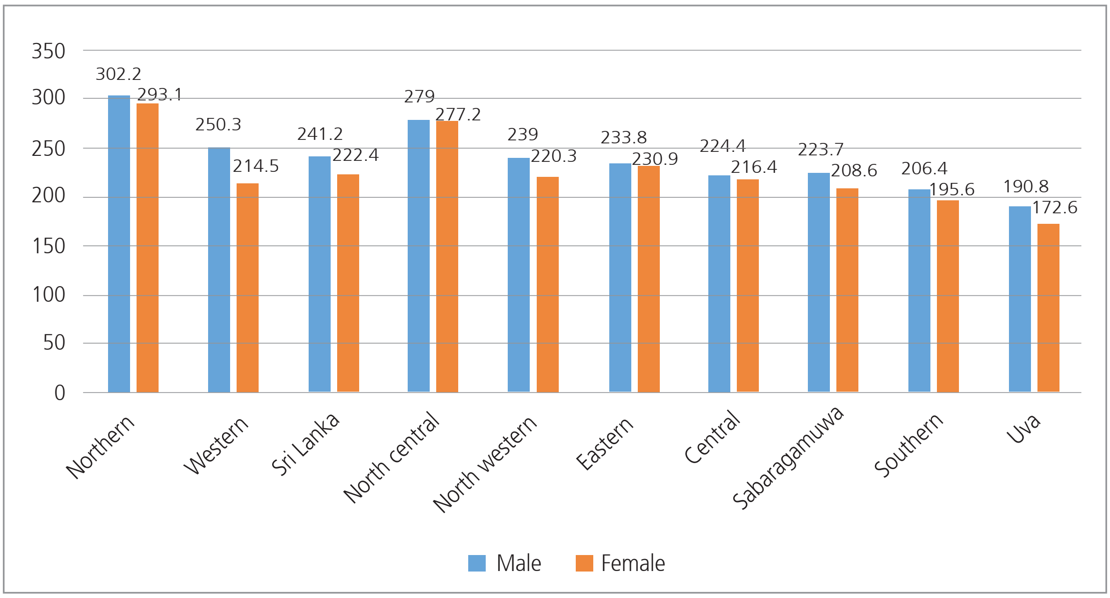


Figure 3: Urine iodine excretion of school children by province 2005, 2010 and 2016

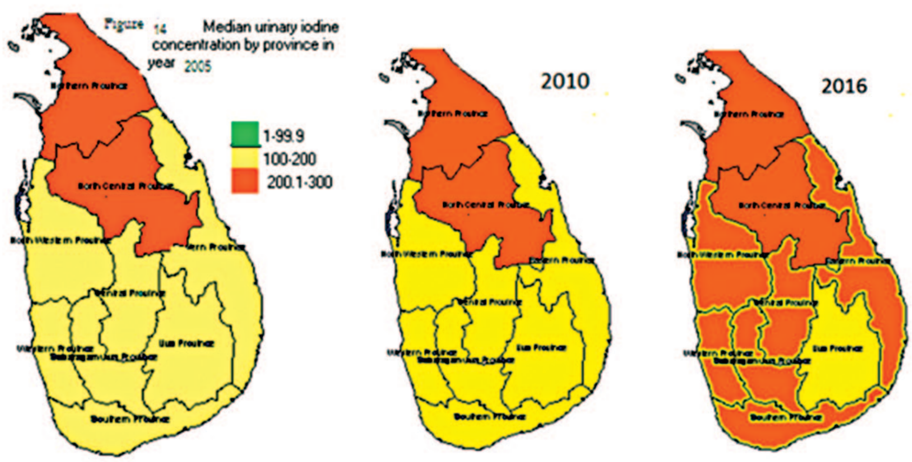


Figure 3 shows the changing pattern of median urinary iodine levels in provinces from 2005 to 2016. Currently all the provinces median urinary iodine levels were above 200 µg/L except in Uva province.

5 Iodine Content of Salt

5.1 Estimation of iodine levels in salt samples from households

Each school child who participated in the goitre assessment was requested to bring a sample of salt from his/her home and iodine levels were estimated by the titration method. Of the children included in the study, 68 percent of the participants brought samples of salt from ‘home’. A total of 5516 salt samples were available for analysis.

As shown in table 5, the median iodine content was higher than the required 15 parts per million (PPM) in all provinces and was relatively similar in all provinces. The lowest median iodine levels were seen in the Western and North Central province (19 ppm) and the highest, in the Central province (26.5 ppm).

Table 5: Level of iodine in salt (ppm) at household level by provinces

Province	Total No. of salt samples examined	Median	25^{th} – 75^{th} percentile
Western	714	19.0	14.8 – 25.4
Southern	564	20.1	13.8 – 25.4
Central	579	26.5	21.2 - 32.8
Northern	484	22.2	18.0 – 26.5
Eastern	710	23.3	20.1 - 27.5
North Western	639	20.1	12.7 – 25.4
North Central	528	19.0	12.7 – 24.3
Uva	630	21.2	16.9 – 25.4
Sabaragamuwa	668	22.2	16.9 – 28.6
Sri Lanka	**5516**	**21.2**	**15.9 – 26.5**

As shown in table 6, only 3.1% of samples were not iodized and 18.4% were inadequately iodized with 5-14.9ppm. The highest percentage of samples with no iodine or inadequate iodine content (< 15.0 ppm) was reported from the North Central Province (32.5 percent) and the lowest from the Central province (10.2 percent). For all samples, 63.5 percent had iodine levels within the permitted range, i.e. 15-30 ppm. It was observed that 15.0 percent of salt samples had iodine values higher than the permitted range (above 30 ppm), this percentage being highest in Central province (36.1 percent) and lowest in North Central province (8.0 percent). 78.5% of households were using adequately iodised salt according the global recommendations (>15ppm).

Table 6: Frequency distribution of iodine level in salt at household levels by provinces

Province*	Percentage of the samples examined	Frequency distribution of samples (as a %)according to the level of iodine content in salt in ppm (n=5516)			
		No iodine (< 5 ppm)	Inadequate iodine (5-14.9 ppm)	Adequate Iodine (15-30.0 ppm)	Excess iodine (> 30 ppm)
Western	12.9	2.5	26.1	60.2	11.2
Southern	10.2	4.4	25.0	57.8	12.8
Central	10.5	0.5	9.7	53.7	36.1
Northern	8.8	1.4	15.5	66.5	16.5
Eastern	12.9	1.1	7.5	79.3	12.1
North Western	11.6	10.3	20.2	59.8	9.7
North Central	9.6	4.5	28.0	59.5	8.0
Uva	11.4	1.9	17.6	68.7	11.7
Sabaragamuwa	12.1	1.3	17.1	62.9	18.7
Sri Lanka	**100.0**	**3.1**	**18.4**	**63.5**	**15.0**

Figure 4: Distribution of iodine level in salt (ppm) at household level in Sri Lanka 2005 - 2016

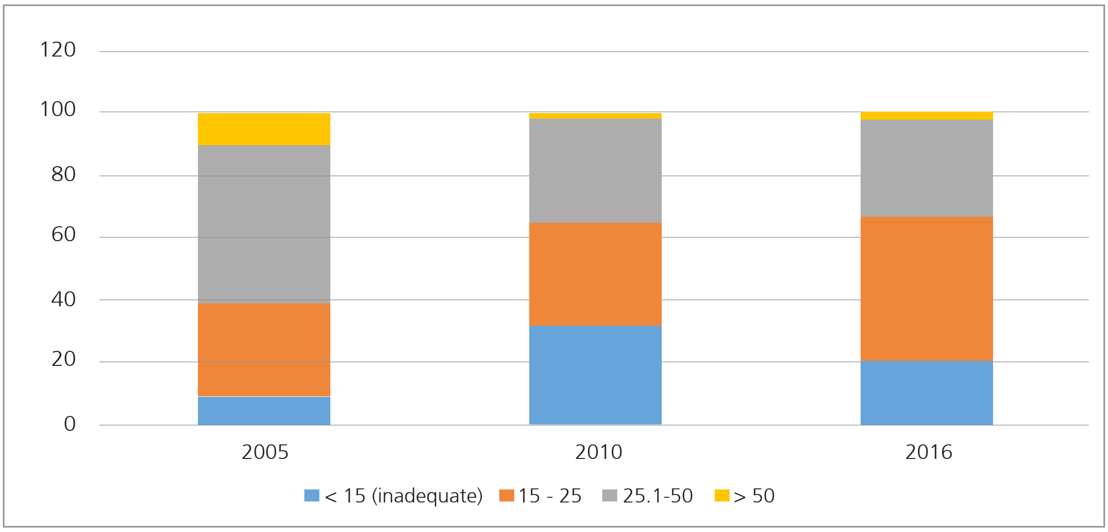


Figure 4 shows the improvement in level of iodine in salt over the years, with the reduction of high level of iodine in salt.

Practices of using iodized salt

The following data are from the questionnaire administered to mothers of children with the consent form to assess practices of using iodized salt

Figure 5: Most common salt purchased by households

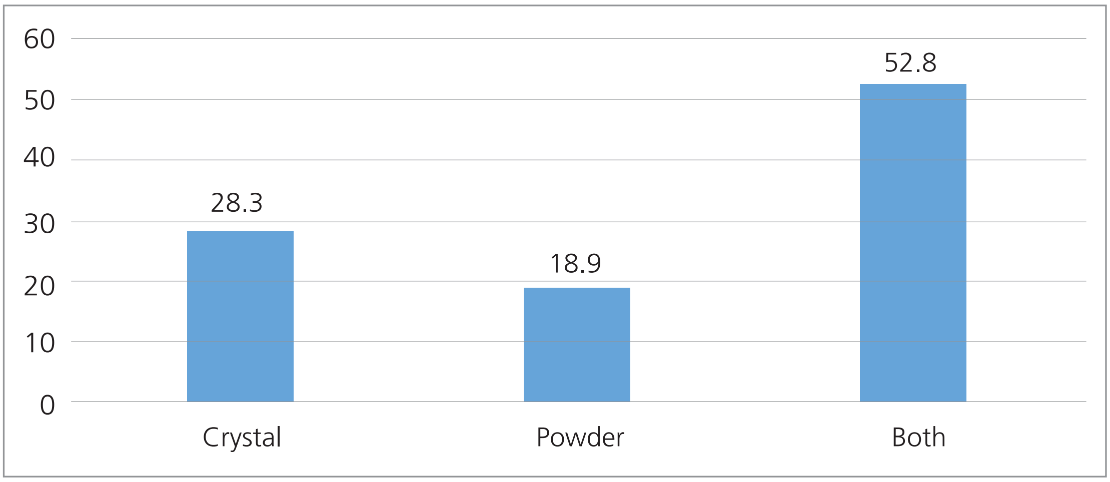


Figure 6: Washing the salt prior to use at household level

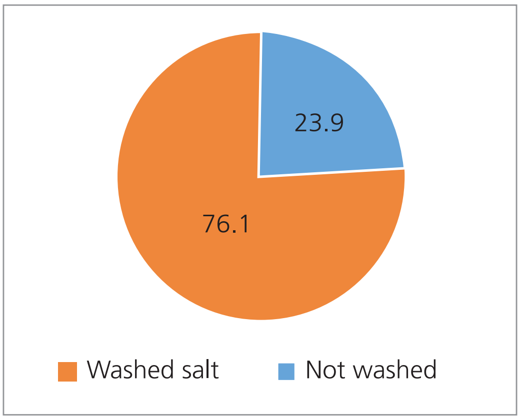
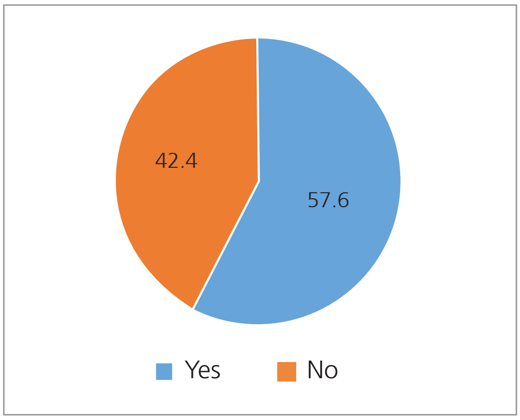


Figure 7: Salt kept in a bottle as a liquid, prior to add into food



As shown in Figures 5, 6 and 7 majority (52.8 percent) of households used both crystal and powdered salt, 23.9 percent washed it prior to use and 57.6 percent kept salt in a bottle as a liquid. This is a common practice in Sri Lanka to keep the salt as a liquid in a bottle to be added to food during cooking.

5.2 Salt producers

There are about 280 salt producers in Sri Lanka, of which 5 are major producers who have 70-80% share of the salt market. Twenty salt producers were visited; all the major producers and 7 and 8 of the medium scale and small scale manufacturers respectively. Majority (80 percent) used wet mixture for iodization and others do repackaging. According to the Food Act, all categories of salt producers have to do periodic testing of samples to assess iodine levels under the labelling regulation.

Figure 8: Testing of iodine content by producers and repackers

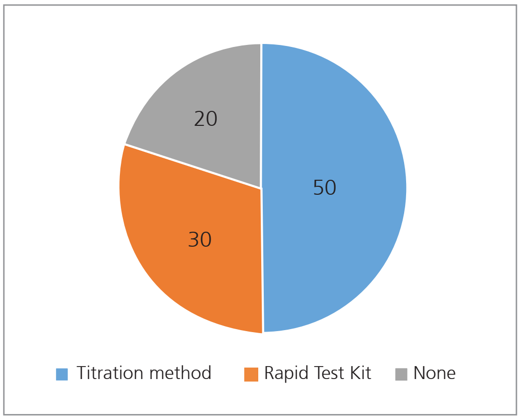


Figure 8 shows 50, 30 and 20 percent of producers and repackers used titration method, rapid test kits and not testing iodine during the production respectively. It was observed that all the test kits had passed the expiry date.

5.3 Labelling of packets, storage and potassium iodate

In accordance with the labelling regulation, all the inspected salt packet had batch numbers, and iodine values in ppm. About 80 percent of iodised salt were packeted and stored for some period of time in 'bulk'. Of them 85% were not tested for iodine prior to distribution. Regulations require all salt producers including repackers to obtain permits from the Ministry of Health to iodize salt, every two years: the majority of iodine permits were issued in 2013, except one in 2014 and another in 2015 (i.e. those issued in 2013 should have been renewed in 2015). Potassium Iodate was directly imported by one large scale salt producer and others are supplied by private companies; 41 percent purchased potassium iodate monthly and prices ranged from Rs. 4,800 – 12,500 per kg. About 52.6 percent of common salt purchased by the small scale producers for iodisation were not washed properly to meet the criteria specified in the Food Act.

5.4 Estimation of iodine level in salt samples obtained from manufacturers

148 samples of salt were collected from the 20 salt producers and repackers visited. Iodine content in the two main types of salt, crystal form and in powder form, was assessed and the results presented in Table 8 show that among the salt samples obtained in the crystal form, 52.4 percent has inadequate iodine levels with none of the samples having excess iodine. Assessment of iodine levels in the salt samples in powder form, showed that 23.6 percent of the samples had inadequate levels of iodine with 18.9 percent having excess iodine. As only twenty out of 280 salt producers were included in the sample, it is possible the samples may be not representative of the national situation although the 20 salt producers and repackers visited all of the major large scale producers.

Salt manufactures suggested few areas to be improved with the iodisation process; common lab at local level to test iodine, increase upper level of iodine in salt, provision of potassium iodate at affordable price and through reliable suppliers and tax concession for equipment.

Table 7: Frequency distribution of iodine level in salt at production levels by type of salt

Type of salt	Number of samples examined	Frequency distribution of samples as % according to salt iodine level (ppm)			
		No iodine (< 5 ppm)	Inadequate iodine (5-14.9 ppm)	Adequate Iodine (15-30.0 ppm)	Excess iodine (> 30 ppm)
Crystal (1-10mm)	42	4.8	47.6	47.6	0.0
Powder	106	0.0	23.6	57.5	18.9
Sri Lanka	**148**	**1.4**	**30.4**	**54.7**	**13.3**

All available brands of salt samples of the salt producers at the time of the visit were included as samples. Iodine levels among the samples from different brands of salt, from different manufacturers are presented in Table 8. A total of 27 brands were analyzed for salt content.

Table 8: Iodine content of salt (ppm) at production level by brands

Code of salt brand	Number of samples	Percentage of samples by Iodine level (ppm)			
		No iodine (< 5 ppm)	Inadequate iodine (5-14.9 ppm)	Adequate Iodine (15-39.9 ppm)	Excess iodine (> 40 ppm)
1	4	0.0	0.0	75.0	25.0
2	3	0.0	100.0	0.0	0.0
3	1	0.0	100.0	0.0	0.0
4	6	0.0	0.0	100.0	0.0
5	3	0.0	100.0	0.0	0.0
6	3	0.0	0.0	100.0	0.0
7	12	0.0	8.3	83.3	8.3
8	6	33.3	66.7	0.0	0.0
9	12	0.0	25.0	75.0	0.0
10	3	0.0	0.0	100.0	0.0
11	3	0.0	0.0	100.0	0.0
12	8	0.0	25.0	75.0	0.0
13	3	0.0	0.0	100.0	0.0
14	6	0.0	50.0	50.0	0.0
15	3	0.0	0.0	100.0	0.0
16	6	0.0	83.3	16.7	0.0
17	3	0.0	0.0	0.0	100.0
18	3	0.0	100.0	0.0	0.0
19	6	0.0	0.0	100.0	0.0
20	3	0.0	100.0	0.0	0.0
21	3	0.0	100.0	0.0	0.0
22	6	0.0	0.0	50.0	50.0
23	6	0.0	50.0	50.0	0.0
24	3	0.0	0.0	0.0	100.0
25	12	0.0	16.7	83.3	0.0
26	6	0.0	0.0	100.0	0.0
27	3	0.0	0.0	100.0	0.0
Total	**148**	**1.4**	**30.4**	**54.7**	**13.3**

Table 8 shows the iodine content of different salt brands. It was observed a given salt producer may manufacture one or more brands, which may be powder or crystal. Of the salt samples tested, those from brand No. 8, had no iodine in one third of samples. Among the other brands, none had no iodine, one third had inadequate iodine levels of 5-14.9 ppm, 54.7 percent had adequate levels of 15 – 30 ppm with 13.5 percent having excess iodine (>30 ppm).

6 Iodine Content of Drinking Water

A total of 652 drinking water samples were collected from the available sources of drinking water in the locality of the school from varied sources, such as taps, wells, tanks, tube wells etc. This is 80.5% of the intended sample of 90 samples per province.

As shown in Table 10, the lowest median iodine values were observed in samples from the Uva province (5.4 μg/L) and the highest values in samples from the Northern province (53.4 μg/L).

Table 9: Level of iodine (μg/L) in drinking water by provinces

Province	No. of samples	Median iodine levels	25th – 75th percentile
Western	72	16.0	4.6 – 29.1
Southern	68	18.0	4.8 – 30.1
Central	73	22.4	6.4 – 42.8
Northern	86	53.4	27.4 -78.4
Eastern	72	17.6	3.4 – 32.7
North Western	86	12.9	6.2 – 61.2
North Central	66	33.0	12.3 – 74.4
Uva	49	5.4	3.4 – 9.7
Sabaragamuwa	80	20.9	8.8 – 37.1
Sri Lanka	**652**	**21.3**	**6.2 – 46.0**

Of all water samples tested, 20.5 percent did not have any iodine, 20.2 percent had iodine levels (5-14.9 ppm) with 37.4 percent having iodine levels of more than 30ppm. (Table 10).

Table 10: Frequency distribution of iodine level in drinking water by province

Province*	Percentage of samples examined	Iodine level in water % (ppm)			
		(< 5)	(5-14.9)	(15-30.0)	(> 30)
Western	10.9	25.4	22.5	29.6	22.5
Southern	10.3	25.4	22.4	26.9	25.4
Central	11.2	19.2	19.2	20.5	38.4
Northern	13.3	8.1	8.1	17.4	**72.1**
Eastern	10.9	11.3	11.3	32.4	28.2
North Central	13.3	37.2	37.2	5.8	39.5
North Western	10.2	13.6	13.6	22.7	50.0
Uva	7.6	34.7	34.7	10.2	12.2
Sabaragamuwa	12.3	16.3	16.3	31.3	33.8
Sri Lanka	**100.0**	**20.2**	**20.2**	**21.9**	**37.4**

7 Current Status of Iodine Deficiency in Sri Lanka

Although median urinary iodine concentrations were lower for children with non-iodized or inadequately iodized salt in their household, they nevertheless had adequate iodine status (>100ug/L). This suggests they are consuming iodine from sources other than household iodized salt, such as intrinsic iodine in foods or iodine from salt used in processed foods. Iodine levels in drinking water in Northern and North Central provinces were higher than in other provinces may be contributing to higher iodine status of school children noted in those provinces.

Table 11: Median urine iodine level by salt iodine level

Salt iodine (ppm)	Total number of samples examined	Median urinary iodine concentration (μg/L)	25^{th} -75^{th} percentiles of urinary iodine values (μg/L)
<5.0	115	216.9	138.7 – 304.0
5.0-14.9	683	216.7	138.7 - 304.5
15.0-30.0	2295	225.1	155.3 – 310.5
>30	533	235.7	171.2 – 320.2
TOTAL	**3626**	**225.2**	**159.3 – 315.8**

Median urinary iodine levels are used to classify countries into difference categories of iodine status of populations. As shown in table 12, in the survey carried out in 2000, the median iodine levels in all provinces and at national level showed 'optimal' iodine status. In 2016 also all provinces as well as the national level data indicated "optimal" iodine levels.WHO suggests that median urinary iodine levels >300ug/L leads to iodine induced hyperthyroidism over the years.

Indicators used in assessing the iodine status in populations include, among others, the total goiter rate (TGR) and the median urinary levels of the population. WHO recommends, total goitre prevalence reflects population's history of iodine nutrition but not its present status as goitre responses slowly to changes in iodine status. However, TGR is considered to have a role in evaluation of long term impact of a control programme. It should be noted however that goiter can be caused by both inadequate and excessive iodine intake

Table 12: Iodine deficiency status in Sri Lanka

Province*	Total goiter rate Status of iodine deficiency		Median urinary iodine levels in ug/L Status of iodine deficiency	
	2000	**2016**	**2000**	**2016**
Western	16.3 Mild	1.1 none	151.4 Optimal	233.1 Optimal
Southern	17.1 Mild	0.7 none	122.4 Optimal	201.3 Optimal
Central	24.2 Moderate	2.4 none	122.5 Optimal	220.7 Optimal
Northern	19.4 Mild	0.6 none	135.9 Optimal	297.3 Optimal
Eastern	25.6 Moderate	1.6 none	139.5 Optimal	233.8 Optimal
North western	-	3.0 none	194.4 Optimal	229.4 Optimal
North Central	26.2 Moderate	1.3 none	231.5 Optimal	278.0 Optimal
Uva	25.9 Moderate	1.6 none	96.2 Mild	178.8 Optimal
Sabaragamuwa	17.3 Mild	4.0 none	181.0 Optimal	217.5 Optimal
Sri Lanka	**20.8** **Moderate**	**1.8** **none**	**145.3** **Optimal**	**232.5** **Optimal**

8 Conclusions and Recommendations

8.1 Conclusions

1. This survey found the total goitre rate (TGR) to have declined further from previous surveys and to well below the public health cut-off of 5% indicating overall thyroid health amongst school age children.

2. The median urinary iodine levels in all provinces were within optimal level range of 100-299µg/L[9] suggesting optimal iodine status in school age children in Sri Lanka. Moreover, the median urinary iodine concentration was optimal in all provinces. This survey did not assess iodine status in other population groups however, such as reproductive age and pregnant women which are priority target groups for iodine interventions as iodine deficiency in these population groups can have severe impacts on children born to these women. Iodine status of pregnant women was assessed in the National Nutrition and Micronutrient Survey of Pregnant Women in 2015[10].

3. The median iodine content in household salt samples was higher than 15 ppm in all provinces and 63.5% of households were found to be using adequately iodized salt (15-30ppm). Only 3.1% of households were consuming non-iodized salt. However, 18.4% of salt samples collected from households were inadequately iodized and 15% were over iodized suggesting a need for improved quality assurance by

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9. Zimmermann MB, Aeberli I, Andersson M, Assey V, Yorg JAJ, Jooste P, et al. Thyroglobulin Is a Sensitive Measure of Both Deficient and Excess Iodine Intakes in Children and Indicates No Adverse Effects on Thyroid Function in the UIC Range of 100–299 µg/L: A UNICEF/ICCIDD Study Group Report. J Clin Endocrinol Metab [Internet]. 2013 Mar 1 [cited 2017 Jul 6];98(3):1271–80. Available from: https://academic.oup.com/jcem/article-lookup/doi/10.1210/jc.2012-3952

10. Jayatissa R, Fernando D, Herath H. National Nutrition and Micronutrient Survey of Pregnant Women 2015. 2017.

producers of iodized salt. It should be noted however that as school children were asked to bring samples of salt to school for testing, and the response rate was only 64%. Therefore, the results should be interpreted with caution.

4. Samples collected from 20 salt producers and repackers during unannounced visits suggest a slightly poorer situation with only 55% of samples with adequate iodization levels (15-30ppm) and a greater proportion of inadequately iodized salt (30%). These data may be more reflective of the national situation and support the need for greater quality assurance by salt producers.

5. The iodine levels in the water samples was low overall, although it is possible that iodine in drinking water may have contributed to slightly higher urinary iodine levels in Northern and North Central provinces.

6. Although it is expected that household iodized salt would be the greatest contributor to iodine intake, it is notable that children in households with non-iodized or inadequately iodized salt have optimal iodine intakes. This could be because the iodine levels of salt in the samples of salt brought to school on the day of the survey are not reflective of the salt normally consumed in the household or the children are receiving iodine from other sources such as intrinsic iodine in foods or processed foods made with iodized salt.

7. Overall the findings of the survey indicate a well-functioning salt iodization programme that is contributing to adequate iodine status in school age children in Sri Lanka.

8.2 Recommendations

1. Facilitate and encourage salt producers to improve iodization and quality assurance practices in order to reduce the amount of inadequately and excessively iodized salt. Before the next survey, results from government monitoring of salt producers should be reviewed to ensure a greater proportion of salt is iodized according to national standards (15-30ppm).

2. In the next survey, assess the iodine status of reproductive age women and pregnant women as these are important target groups for iodine interventions and the iodine status of school age children is not necessarily reflective of these important population groups.

3. As school age children appear to be consuming iodine from sources other than household iodized salt, an assessment should be made of the contribution of processed foods to salt and iodine intake. This data can be used to further fine-tune the programme. For example, if processed foods are contributing substantially to salt intake but not all processed foods are being made with iodized salt, this aspect of the current salt iodization legislation should be more strongly enforced.[11]

11. Sri Lanka's Regulation under Section 32 of the Food Act, No 26 of 1980 – Food (Iodization of Salt) Regulations, 2005 require the iodization of all salt for human consumption, including salt used as an ingredient of food and for food manufacture.