Progress and challenges with salt iodisation programme in Sri Lanka

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ABSTRACT

Background: Iodine deficiency was recognised as a public health problem in Sri Lanka following the 1986 national survey that documented total goitre prevalence of 18.2%. In 1995, the government of Sri Lanka launched "Universal Salt Iodisation" as the mainstay of iodine deficiency control. With strong private-public partnership and financial and technical support from external development partners, the coverage of household consumption of iodised salt increased from 46% in 1996 to 92% in 2006 and the goitre prevalence reduced from 20% to 3.8%. This followed by reduction of the salt iodisation level from 25ppm to 15ppm with continued partnership with salt producers.

Aim: The aim of this study was to assess the progress of salt iodisation programme in Sri Lanka, 15 years after initiation of the programme.

Methods: A total of 1,900 school children of 6-9 years from 60 clusters (school) were studied. Thirty schools were randomly selected from provinces that demonstrated urine iodine levels between 100-200µg/L in 2000 survey and other 30 schools were selected from provinces with urine iodine levels below 100 and above 200µg/L. Thirty children were randomly selected from each school for the study. Goitre prevalence by palpation and iodine levels in casual urine samples were assessed. Household salt iodine levels were determined by titration method using salt brought by students from their homes.

Results: The total goitre prevalence was 3.8% (CI=3.0- 4.7). Median urinary iodine concentration in 1,879 samples was 154.4µg/L ranging from 6.1 to 1754.8µg/L. The results of the study in 1,594 samples also showed that 91.2% of households consumed iodised salt. The frequency distribution of urinary iodine levels shows that 34.7% of the children had urine iodine levels in the 'adequate' range with 30.9% with lower values (<100µg/L) and 35.5% with higher values (≥200µg/L). Only 0.1% of children had very low urinary iodine values of <20µg/L. Comparison of the results of this study is compared with the study carried out in year 2000 showed a reduction in the goitre rate from 20.1% to 3.8%; increased urinary iodine levels from 145.3µg/L to 152.5µg/L and the increased household consumption of iodised salt from 49.5% to 91.2%.

Conclusions: With private-public partnership and financial and technical support from external development partners, Sri Lanka has achieved the goals of eliminating iodine deficiency as a public health problem. The challenge ahead is sustaining the gains and achievements made through the programme.

Key words:
Iodine deficiency, goitre, urinary iodine, salt iodine

INTRODUCTION

Iodine deficiency is the world's single most significant cause of preventable brain damage and mental retardation. Nearly two billion people in the World may be at risk for iodine deficiency, and recent estimates suggest that 15.8% of people experience some degree of goitre. Over one third (37%) of school age children Worldwide (a total of 285 million) are iodine deficient. Approximately 40% of the burden occurred in the South East Asia Region (SEAR)[1].

Sri Lanka is an island situated in the Indian Ocean with a most beautiful coast line with relief features like bays, lagoons and capes. The hilly region in the centre of the island with its mountain ranges, waterfalls, plateaus, valleys and rivers are the components of the scenic beauty of the country. Sri Lanka consisting of nearly 19 million population is situated in the northern hemisphere close to the equator between latitude of 5 and 10 degrees. It is administratively divided into 9 Provinces and 25 Districts.

Studies that have been made since 1947 indicated that there was an endemic goitre belt in the south-west region of the country, which constitute the wet zone of Ceylon (before called Sri Lanka)[2]. Apart from this several studies indicated that there was a mild to moderate prevalence of goitre. Cretinism was not an extensive problem from the beginning and absence of deaf-mutes may have been due to the relatively mild nature of iodine deficiency[3].

The first systematic assessment of iodine deficiency disorders in Sri Lanka was conducted in 1986[4]. Although the overall goitre prevalence was 18.2 per cent, the prevalence rates varied from 30.2 per cent to 6.3 percent. In response to the above situation and in line with the goals set by the World Health Assembly and the World Summit for Children in 1990, the government of Sri Lanka decided to embark on iodine deficiency control placing "Universal Salt Iodisation" as the main thrust of the control programme.

Salt is produced locally by 2 major salt producers and around 270 small scale producers. Salt is manufactured by solar evaporation using sea water. Potassium iodate is used for iodisation. Two thirds of iodised salt production is handled by small scale producers. There are a few producers who import iodised salt and packet it for distribution.

In order to support the implementation of salt iodisation programme, the government has passed a law that regulates the production and distribution of iodised salt in the country. This was incorporated into the Food Act and enforced in July 1995[14]. Regulation under this act bans the production, distribution and sale of non-iodised salt for human consumption. The iodine content of salt at household level was considered at 25ppm in the legislation. Since 1992, UNICEF has been supporting the Ministry of Health to control iodine deficiency disorders in Sri Lanka. UNICEF supported the Ministry of Health to build capacity of health workers at peripheral and national levels to monitor the iodine content of salt and evaluate the impact of the programme. This includes the establishment of National Reference Iodine Laboratory at Medical Research Institute (MRI).

The MRI, Department of Nutrition, carried out a national IDD survey in 2000/1 of 2,630 children, 8-9 years old, in all the country's health administrative areas, from 9 Provinces with the support of UNICEF[5]. It relied on the urinary iodine concentration to assess iodine nutrition. The national median urinary iodine concentration was 145.3μg/L. The total goitre rate was 20.1% by palpation method and the 49.5% of salt samples were adequately iodised at household level.

The finding of the year 2000 national study was presented in March 2001 and action plan was developed on iodine control in July 2001. Briefing session was conducted with salt producers at the end of the year 2001 to ensure the regular quality control of salt. The Ministry of Health together with UNICEF took measures to raise the public awareness and demand for iodised salt through awareness creation, social mobilisation and advocacy throughout the island.

After considering the proportion of children with more than adequate levels of urine iodine in the country, which was indicated in the MRI study[5], the legislation was revised in the year 2005, requiring 15ppm iodine in salt at household level[15]. Quality assurance system was established by the food administration unit of Ministry of Health for iodide salt through the public health system. Public health staffs are expected to monitor the iodised salt at production, retail and household level by rapid test kit.

Surveillance programme was initiated in the year 2001 and 4 districts were evaluated every year. The findings of surveillance programme were used to increase awareness among members of National Iodine Committee, relevant officials in the ministry of health, clinicians, salt producers and public health officers and this help to enhance the monitoring mechanism.

In December 2004, Sri Lanka was faced with the tsunami disaster thus the major salterns were affected[16]. As part of the post tsunami initiatives ICCIDD with the assistance of the Micronutrient Initiatives (MI) Asia launched a project to modernise the two major salterns[17].

After considering the above facts, it was decided to conduct a national survey to assess the progress of the iodine nutrition status in the country. Hence this study was conducted under the following objectives; to determine the goitre prevalence, to determine the iodine nutritional status by measuring urinary iodine levels and to measure the iodine levels in the salt at household level.

SUBJECTS AND METHODS

It was a cross sectional nation wide study. The study population was identified as school children aged 6-9 years. In calculating the sample size, the prevalence of goitre (p) was taken as 20%[5]. The 95% confidence interval was applied and the error was taken as 5%. The non response rate was considered as 10%. Because of the clustering effect of schools design effect was taken as 7. Based on these parameters the number of children to be studied during the study was 1800.

Recommended sampling methodology by the WHO/UNICEF/ICCIDD (1992), was followed for the present study[19]. It was intended to conduct this study based on the findings of the previous national survey on urinary iodine levels of the different districts in the country. Accordingly, the entire country was divided into 2 areas; low (where the urinary iodine level was <100μg/L) or high (where the urinary iodine level was >199μg/L) and normal (where the urinary iodine level was between 100-199μg/L. According to the "EPI 30 cluster" methodology, 30 schools were selected from the low or high urinary iodine values and 30 schools were selected from the normal urinary iodine values. During the first stage of sampling proportionate stratification was done to identify the number of schools in the low / high and normal areas according to probability proportional to population size (PPS) in each district. During the second stage of sampling all schools in each district were listed with the population of children between 6-10 years of age. The selection was done according to probability proportional to population size (PPS).

The study population (respondents) consisted of male and female children in the age group of 6 to 9 years. According to the total sample size of 1800, a sample size of 30 per school is required to achieve the 60 schools. During the third stage of sampling, all classes with children in grade 2, 3 and 4 classes were listed out because the children of the chosen age groups are in these classes. One class from each grade was randomly selected by using lots.

Ten children were selected from each selected class from the attendance register by using computer generated random numbers. A total of thirty children from each school were included for the assessment. In some classes when the numbers of students were 10-15, all the children were included for the assessment. However, it was found that some schools had less than 30 children. In such cases all the children were included and the balance was taken from the adjacent school from the same district or Province.

During the study the following components are assessed; clinical examination for goitre, estimation of iodine in a casual sample of urine, assessment of iodine content of a sample of salt brought by the child from the household. A structured format was developed to obtain identification data, birthday and sex of children in the selected classes and the information was obtained from the attendance register and marked on the format by a member of the study team.

A group of 10 public health inspectors were trained as field investigators to assess the goitre status of the study group. They had an experience of examining goitre during the national survey conducted in 2000. A theoretical and practical training for assessment of goitre was conducted prior to the survey.

Clinical examination for goitre: Selected children in schools were assessed for the presence/absence of goitre. Grading of goitre was done according to the WHO/UNICEF/ICCIDD criteria as follows[19]; grade 0: thyroid not palpable not visible, grade 1: thyroid palpable but not visible with neck in normal position and moves up wards in the neck as the subject swallows and grade 2 - goitre visible with neck in normal position and consistent with enlarged thyroid when the neck is palpated.

Measurement of urine iodine: Casual sample of urine for estimating urinary iodine was obtained from selected 30 children, from each school. A total of 1800 urine samples were collected. Each child was provided with a disposable paper-cup with a wide mouth and was requested to collect the urine sample, by urinating directly into the cup. Members of the study team, wearing disposable gloves, transferred approximately 5 ml of the urine specimen from the cup to a tight fitting screw-capped plastic container. The remaining urine and the cups were disposed of appropriately.

The urine samples were labelled with identification data for the province, school and the child (in that order). All 30 samples were stored in a large plastic container and this package was marked with the province and school and then transported for storage. Samples were transported to the area Divisional Drug Stores and stored at -4^{0}C. They were transported to the laboratory of the Nutrition Department of Medical Research Institute (MRI) every week with cold packs and stored at -20^0 till taken for analysis. The method of assessing iodine concentration was the modified micro plate method, which is the simplified method adopted from Pino Method[19].

All samples were analysed by the trained Medical Laboratory Technologists (MLT). Quality control analysis was carried out throughout by using samples with known iodine values. The urine samples were tested on "first arrived - first assessed" basis. The results were entered into the computer data sheet with the labelling details.

Estimation of iodine content of salt at household level: Children have brought a sample of salt from home, in a polythene pack. The level of iodine in the salt samples was determined with rapid field test kits (MBI-India) and the titration method. The salt samples were classified according to their iodine levels in regard to the colour change observed with the rapid test kit.

Five teams were deployed for the study. Each team comprising of 2 field investigators were responsible for data collection. All selected schools were informed about the study. The consent forms were distributed to all children in the selected classes prior to the study to obtain the consent of the parents/guardians. The schools were informed the date of the visit and the selected students from the selected class were requested to bring salt samples on that day. All fieldwork was completed during September - October 2005.

The data entry and analysis was carried out using the EPI/INFO software package. Informed written consent was obtained from the parents by a letter from the Principal Investigator forwarded through the class teacher. Permission was obtained from the Education authority and Provincial Directors of Health Services for the study. Ethical clearance was obtained from the ethical committee of Medical Research Institute.

RESULTS

A total of 1900 children aged 6-9 years from 9 provinces were studied. Of them, 964 (50.7%) were males and 936 (49.3%) were females. The mean age of children was 8.4 (SD=1.2) years.

Prevalence of goitre

All the children were palpated for goitre. Among this group, 3.5% had Grade 1 goitre and 0.3% had Grade 2 goitre, giving a total goitre rate (TGR) of 3.8% (Table 1). The total goitre prevalence varied between provinces with the highest prevalence noted in the Central Province (10.3%) and the lowest in the Southern and Northern Provinces (0.5%). The prevalence of total goitre rate was higher among females (4.7%) than among males (3.0%).

Urinary iodine levels

Table 1 show the urinary iodine concentration in 1879 casual urine samples from school children aged 6-9 years which was 98.9% of the total children examined. The national median urinary iodine concentration was 154.4μg/L indicating iodine sufficiency. However, North Central (230.0μg/L) and Northern Provinces (283.4μg/L) indicated high level of median urinary iodine concentration recommended than normal (>199μg/L)[19]. The distribution of urinary iodine concentration in different Provinces indicating optimum urinary iodine levels in 7 out of 9 Provinces in the country and more than adequate iodine level in Northern and North Central Provinces.

Study of the **frequency distribution of urinary iodine levels by province** shows that 34.7% of the children had urine iodine levels in the 'adequate' range with 29.9% with lower values and 35.5% with higher values (Table 2). Of those who had lower values, only a small percentage (0.1%) had very low values of <20μg/L. Seven provinces has shown zero values below 20μg/L and in Western and Southern Province percentage was 0.5%.

The group that had iodine levels of above 300μg/L indicating a possible excessive iodine intake, the percentages ranged from 6.8% in the Uva and Southern Provinces and 43.5% in the Northern Province. It must be noted that of the 184 urine samples studied from the Northern Province, 69% had values higher than the 'adequate' value, compared to 20% in the Uva province.

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 house and test kits were used to determine the level of iodination. A majority of children i.e. 83.9% brought samples of salt from 'home'. All the salt samples were brought to the MRI laboratory for testing iodine levels by the titration method.

The iodine content in household salt based on titration of 1594 samples is shown in Table 6. The mean iodine content in household salt was 28.0ppm where it is recommended that the iodine content of household salt be in the range of 15-25ppm. However, there are Provincial variations indicating higher level of iodine content of 32.7ppm in Central Province.

Table 7 shows that over 90% of households had access to adequately iodised salt indicating 91.2% of the samples had iodine levels within the permitted range, i.e. 15ppm. It was observed that 61.0% of salt samples had iodine values higher than the permitted range (above 25ppm) and only 8.8% had lower values. Of the samples with very low iodine values, i.e. less than 15ppm, the highest percentage was seen in the Northern Province (27.7%). Northern Province has low values compared to other Provinces.

After testing for titration the remaining salt samples (n=1423) were tested with rapid test kit. For a sample of salt to be considered as 'adequately iodinated' the colour has to change to purple indicating an iodine content of 15ppm. According to this specification, only 89.2% of the samples were 'adequately iodinated' (Table 8). The lowest percentage of samples with adequate iodination was seen in the Southern province, i.e. 82% and highest in Western province, i.e. 95.9%.

Comparison with previous studies

Goitre rates were compared from 1986 – 2005 and it shows a marked reduction of goitre rates in each Province and there is a reduction of goitre rates in all Provinces (Figure 1). Figure 2 presents that almost all the Provinces have been maintaining an adequate level of urine iodine since 2000. On the other hand, it showed high iodine content among children living in the Northern Province. Figure 3 indicates the significant increase of salt iodine levels at households from 1995. Southern and North Western Province showed the lesser percentage of iodine levels in salt compared to the other Provinces. Figure 4 presents the correlation of urinary iodine levels with salt iodine levels indicating positive correlation with increasing level of iodine in salt.

Discussion

Salt iodisation is by far the most important population-based intervention for IDD control and has been shown to be efficacious in alleviating IDD assuming iodine concentrations in the salt are at appropriate levels at the time of consumption.

Median urinary iodine and the prevalence of goitre are the most important indicators for assessing IDD and for describing the severity of IDD as a public health problem. School age children are the most appropriate target group for IDD surveillance. Urinary iodine is a marker of very recent dietary iodine intake. Palpation becomes less reliable when average goitre size decreases in a population. Ultra-sonography then provides a more precise and objective method.

The benchmark for monitoring progress towards elimination of IDD as a public health problem is 50% of the target group with urinary iodine below 100ug/L and less than 20% with levels below 50ug/L. Median urinary iodine was above 100ug/L at all sites visited. This is a major public health success, given the remote location of the sites and their long histories of IDD. The prevalence of goitre had decreased in all sites investigated (compared with the period before salt iodisation), but goitre rates were still not below the 5% mark, designated as a criterion for the elimination of IDD.

The high prevalence in the Central Province is of special significance as this province is situated at the highest elevation from the sea level ranging from 250 – 2500 sq. meter. The highest rate of grade 2 goitre (1.5%) was also detected in Central province. Figure 13 indicates that the goitre is no more a public health problem in 6 out of 9 Provinces in the country.

Out study shows that goitre rate has decreased from 20.1 to 3.2 in year 2005. Sri Lanka maintains the median urinary iodine values between 100-200ug/L for last 10 years. Household level iodisation has gone up from 49% to 91.8% in the year 2005. It shows that Sri Lanka has shown a remarkable achievement and arrived at goals in eliminating iodine deficiency disorders that were identified by the WHO/ICCCD/UNICEF 10 years after the iodisation. It takes longer, however, to correct the prevalence of goitre than to correct urinary iodine after the implementation of universal salt iodisation, according to a recent study of seven African countries.

It is interesting to note that even at present there is a goitre prevalence with a public health significance in the south-west region of the country which was defined as the goitre belt in 1947. It indicates that a close monitoring is needed to prevent the re-emergence of IDD as a public health problem.

On the other hand, it showed high iodine content among children living in the Northern Province which clearly indicates that they ingest more iodine than their counterparts living in other Provinces. The most likely explanation is high iodine levels in the drinking water in Northern

Province in addition to the iodine in salt. On the other hand, a significant proportion of urine samples in North Central and Northern Provinces showed iodine contents that were high signalling the need for strengthening the quality assurance systems at different levels.

Southern and North Western Province showed the lesser percentage of iodine levels in salt compared to the other Provinces. These are the two Provinces in which the two major salterns are situated thus people have access to get non iodised salt. This highlights the need for increasing awareness on benefits of iodised salt among people in these Provinces.

- inter-sectoral national iodine committee covering all the involved institutions and , .

1. Maintain the provision of technical and logistical capacities for the assessment of iodine in salt and urine at National Reference Laboratory to facilitate the sustainability.
2. Integrate indicators of IDD elimination into the national system of health information, in particular the household coverage of iodised salt.
3. Ensure annual surveys of iodine status in risk-prone districts.
4. Conduct nationwide IDD survey every five years.
5. Support operational research in the field of eliminating IDD
6. Salt producers should verify the salt quality prior to purchase from salterns.
7. Register all the salt producers under the Ministry of Health for easy follow up.
8. Arrange the facilities to obtain rapid test kits for salt producers and to establish laboratory facilities to determine the iodine levels in salt at production.

IDD status among adolescents: In 2004 January, MRI conducted a study among 870 children aged 10-18 years in NuwaraEliya district with the assistance of South East Asian Regional Office (SEARO) of World Health Organisation (WHO) in New Delhi. It revealed that the goitre rate was 3.7% among adolescents and the median urinary iodine concentration was 109.6μg/L ranging from 13.4- 704.8μg/L[6].

Cretinism results from maternal iodine deficiency during pregnancy. It can be prevented by supplementing the mother during pregnancy. It can be prevented by supplementing the mother during pregnancy preferably during the first trimester but no later than the second trimester.

IDD status among pregnant women: A study carried out in 1967 with 2870 pregnant women from 17 antenatal clinics revealed the goitre prevalence ranged from 0.4 – 34.8 percent[7]. Another study conducted by MRI in 1987/88 involving 1235 pregnant women in Kalutara district indicated 65.5 percent of goitre rate[8]. Urine samples of 499 pregnant women were examined in 30 antenatal

clinics of Kalutara district in 2003 revealed that the median urine iodine levels at 120.1μg/L with a range of 7 – 778.1μg/L which indicated an adequate iodine nutrition status among pregnant women in Kalutara district[9].

Finally, elevated serum thyroid stimulating hormone (TSH) in the neonate indicates insufficient supply of thyroid hormone to the developing brain. This is the only indicator that allows prediction of possible impairment of mental development at a population level.

IDD status among neonates: Premawardana (2000) has examined 612 neonates on the 4-5th day after birth and found that Thyroid Stimulating Hormone (TSH) levels have been under 10mU/L in all subjects indicating neonatal hypothyroidism is not a significant problem[10].

Clearly, careful monitoring of the iodine content in commercial salt is necessary, accompanied by reporting of cases of thyrotoxicosis, especially after the recent iodisation of salt. The public health benefits of salt iodisation, however, far outweigh risks from toxicity.

Iodine induced thyrotoxicosis, thyroiditis and thyroid cancer: A study conducted in 2000 reported that there was no evidence of thyroid induced thyrotoxicosis after examining 363 schoolgirls of 11-16 years from Colombo, Kandy, Matale, Kalutara and Galle districts. In the same study it was stated that high age related prevalence of thyroid antibodies (TgAb) ranging 11-69% among schoolgirls[11]. Another study revealed 300 thyroid cancer patients from 1974-2001 and indicated highly significant reduction of anaplastic thyroid cancer and the extent of extra-thyroidal spread at presentation of differentiated thyroid cancer after iodisation in 1995. In contrast a highly significant increase in papillary carcinoma was noted in the post-1996 period[12].

Efforts towards establishing and sustaining national salt iodisation programmes have accelerated over recent years. Effective partnerships have been forged between relevant UN agencies, national and international NGOs, and the salt industry.

The goitrogenic action of iodine deficiency had been aggravated by the long term consumption of poorly detoxified cyanide-rich cassava.

Iodine content of food: Mahadeva et al (1967) shows that the iodine content of the food of people living even in goitre endemic areas was about 300-350μg per person per day, even after allowing for extreme losses amounting to 38% which may occur during cooking, whereas the daily iodine content of the food in Jaffna, which is one of the goitre non-endemic areas, was about 850μg per day[7]. Mean iodine content in 100 gram of food items in the present day market are as follows; full cream milk powder (40μg), cereals (35μg), infant milk formula (77μg) etc.

Iodine content in drinking water: Sri Lanka gets water mainly from rainfall. Some areas of the island get rain throughout the year. Where rainfall is seasonal, water is stored in irrigation tanks, ponds and reservoirs. Where there is no surface water, the water requirements are fulfilled by tapping underground water by means of tube wells. Four hundred and eighteen drinking water samples were tested between 2001-2004 at MRI laboratory and the iodine content in drinking water varied from 0-535.5μg/L[13]. Figure 6 shows the median iodine content of drinking water in different districts.

Despite the magnitude of the IDD problem, great progress has been made in recent years towards its elimination. Effective partnerships have been forged between relevant UN agencies, national and international NGOs, and the salt industry. Several national programmes in which the salt industry has exercised leadership have shown spectacular success and made enormous strides towards IDD elimination. In China, for example, most provinces now have over 90% coverage with iodises salt. The national median urinary iodine is 314ug/L, and all provinces except ….have a median concentration greater than 100ug/L. Adjusted for palpation, the national total goitre rate is estimated as 10.9% by palpation and …..9.6% by ultra-sonography, compared with just over 20% in 1995. The keys to China success are effectively iodised salt, enforcement of regulations, strong commitment by government at all levels, an intensive education programme, and monitoring of salt quality and biological impact. China's success clearly demonstrates how rapid increase in rates of effective salt iodisation can increase urinary iodine levels and decrease goitre prevalence.

Knowledge of the impact of iodine deficiency on mental development has played an important role in mobilizing political leaders, public health officials, nutritionists, and private industry world-wide to launch effective national programmes. Progress towards eleimination of IDD through universal salt iodisation appears to be one of the most significant successes in the field of non communicable disease. There is a strong political commitment by the Minister of Health directing to make proper iodisation standards. A Director Environmental and Occupational Health was appointed as a responsible focal point for IDD elimination program by the Director General of Health Services. National Iodine committee was established with all the stakeholders under the Ministry of Health but ironically regular meetings were not conducted. Public Health Inspectors are expected to test the iodine level of salt at producer, retail and household levels within their respective areas. But the information is not included at the National system of health information.

CONCLUSIONS AND RECOMMENDATIONS

Sri Lanka has eliminated IDD as a public health problem on a national scale. However, there remains the problem of prevalence of mild goitre and problem of non-iodised salt in some Provinces. Though Sri Lanka has attained adequate iodine nutrition status, it needs to continue to pay special attention to IDD endemic areas to avoid IDD return. As IDD can forcefully bounce back despite present efforts and successes, it is recommended to continue an effective surveillance system to maintain the sustainability of USI.

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Table 1

Prevalence (%) of goitre by provinces in 2005

Province*	**No.**	**Total goitre rate***	**Urinary iodine concentration (μg/L)**			
		(confidence limits)	**Median**	**CI***	**Median**	**CI***
Western	192	7.3 (3.6-11.0)	142.2	149.5-184.9	28.5	29.0-32.7
Central	205	10.3	111.0	131.7-	32.7	31.7-

		(6.9-15.5)		160.5		35.9
Southern	211	0.5 (-0.5-1.4)	144.7	145.7-174.4	27.5	27.5-31.1
Northern	190	0.5 (-0.5-1.6)	283.4	323.8-411.7	18.5	19.9-22.9
Eastern	173	1.7 (-0.2-3.7)	160.4	167.3-208.9	29.1	31.1-36.8
North Western	207	1.0 (-0.4-2.3)	152.8	175.5-223.4	28.0	27.8-31.5
North Central	264	0.8 (-0.3-1.8)	230.0	246.6-292.7	28.6	30.8-35.2
Uva	268	7.8 (4.6-11.1)	108.5	128.3-153.1	28.5	30.2-33.7
Sabaragamuwa	190	3.2 (0.7-5.6)	109.0	138.4-175.3	32.0	30.5-34.4
Gender			**154.4**	**190.7-206.7**	28.0	**30.1-31.5**
Male	964	3.0 (1.9-4.1)				
Female	936	4.7 (3.3-6.1)				
Sri Lanka	**1900**	**3.8 (3.0-4.7)**				

Total goitre rate= (grade 1+2) (X^2=73.8, df=8, P=0.000); (X^2=3.7, df=1, P=0.06)

*CI = Confidence Limit (F=41.9, P=0.000)

Table 2

Frequency distribution of urine iodine levels by provinces

Province*	Total examined	Percentage of urine iodine levels (μg/L)					
		Deficiency			No deficiency		
		< 20	20-49.9	50-99.9	100-199.9	200-299.9	>=300
		Severe	Moderate	Mild	Ideal	More than adequate	Excessive iodine intake
Western	192	0.5	4.2	21.9	49.0	15.6	8.9
Central	205	0.0	9.8	33.7	33.2	14.1	9.3
Southern	206	0.5	11.2	21.8	38.8	20.9	6.8
Northern	184	0.0	0.5	4.3	26.1	25.5	43.5
Eastern	170	0.0	10.0	17.1	35.3	25.9	11.8
North Western	204	0.0	4.4	20.6	43.1	14.7	17.2
North Central	263	0.0	2.7	12.2	26.6	25.5	33.1
Uva	265	0.0	12.1	32.8	35.1	13.2	6.8
Sabaragamuwa	190	0.0	11.6	34.7	26.8	13.7	13.2
Sri Lanka	**1879**	**0.1**	**7.4**	**22.4**	**34.7**	**18.7**	**16.8**

(X^2=353.9, P=0.000)

Table 6

Iodine content of salt samples at household level measured by titration method by provinces

Province	No.	Median	CI*
Western	152	28.5	29.0-32.7
Central	179	32.7	31.7-35.9
Southern	156	27.5	27.5-31.1
Northern	173	18.5	19.9-22.9
Eastern	130	29.1	31.1-36.8
North Western	158	28.0	27.8-31.5
North Central	253	28.6	30.8-35.2
Uva	223	28.5	30.2-33.7
Sabaragamuwa	170	32.0	30.5-34.4
Sri Lanka	**1594**	28.0	**30.1-31.5**

*CI = confidence limit; (F=13.7, P=0.000)

Table 7

Frequency distribution of iodine level in salt at household level by provinces

Province	No.	Frequency distribution of samples exposure as % according to salt iodisation level (ppm)			
		<15	15-25	25.1-50	50-100
Western	152	3.9	33.6	55.3	7.2
Central	179	5.6	24.0	57.5	12.8
Southern	156	2.6	39.1	53.8	4.5
Northern	173	27.7	41.6	*28.9*	*1.7*
Eastern	130	9.2	26.9	44.6	19.2
North Western	158	6.3	31.6	56.3	5.7
North Central	253	9.9	27.7	47.4	15.0
Uva	223	5.8	24.7	56.5	13.0
Sabaragamuwa	170	7.6	25.3	58.2	8.8
Sri Lanka	**1594**	**8.8**	**30.1**	**51.0**	**10.0**

(X^2=95.6, P=0.000)

Table 8

Adequate iodination of salt at household level

tested by rapid test kit method by provinces

Province	No.	Rapid test kit (%)	
		No. positive	Confidence limit
Western	146	95.9	92.7-99.1
Central	113	92.0	87.0-97.0
Southern	161	82.0	76.0-87.9
Northern	79	91.1	84.9-97.4
Eastern	152	86.8	81.5-92.2
North Western	150	83.3	77.4-89.3
North Central	233	92.3	88.8-95.7
Uva	217	91.7	88.0-95.4
Sabaragamuwa	172	87.2	82.2-92.2
Sri Lanka	1423	89.2	87.6-90.8

Table 12

Progress of indicators towards eliminating IDD in Sri Lanka

Indicators	Goal	Before iodisation	5 yrs after iodisation	10 yrs after iodisation
Goitre %	<5	20.1	20.9	3.2
Median urinary iodine (μg/L)	100-199	-	149	159
% adequately iodised salt at Household level	> 90	-	49.0	91.8

Figure 1

Comparison of goitre rates in Provinces from 1986 – 2005

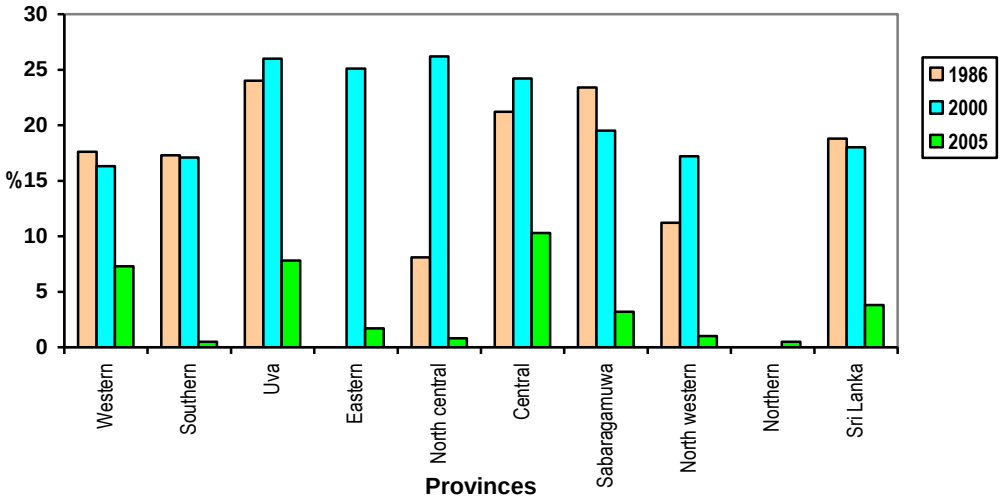

Figure 2

Comparison of urinary iodine levels from 2000 – 2005

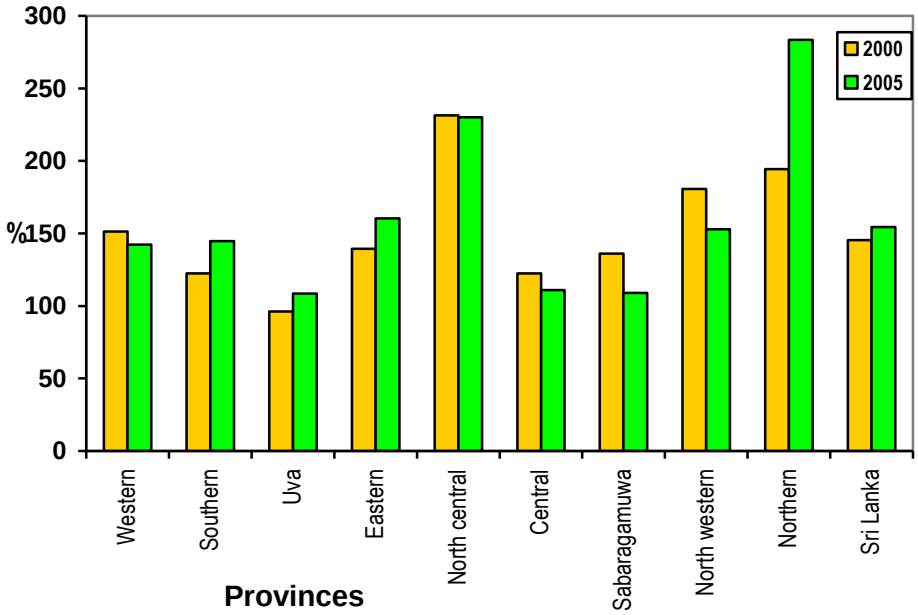

Figure 3

Comparison of iodine levels in salt at household level by rapid test kit from 1995 – 2005