

Title: PROGRESS IN THE FIJIAN IODINE SUPPLEMENTATION PROGRAM.

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Abbreviations:

IDD Iodine Deficiency Disorder

ID Iodine Deficiency

UI Urinary Iodine

ICCIDD International Council for Control of Iodine Deficiency Disorders

UNICEF United Nations Children's Fund

## **Abstract**

Iodine deficiency (ID) can affect fetal development, cause mental retardation and retarded development in children as well as goiter in adults. These iodine deficiency disorders (IDD) were recognized as a public health problem which led the Fijian government to legislate that only iodised salt could be produced or imported as a means by which the population would receive sufficient iodine.

To measure the success of Fiji's elimination of IDD, this study determined the population urinary iodine (UI) levels in children and expectant mothers. Over 1200 urine samples was collected using sentinel survey technique. Children provided salt normally used in their household to determine the proportion of households using adequately iodised salt. In addition, expectant mothers completed a questionnaire which determined the amount of iodine and goitrogens in their diet.

The population UI levels met the criteria set by International Council for Control of Iodine Deficiency Disorders (ICCIDD) for determining success in elimination of IDD. Adequately iodised salt was used by 98% of households. Of the ten recommended programmatic indicators essential for sustained IDD elimination, Fiji had nine in place. Only 2 (maize flour and soy milk) of the 39 food items considered in the diet of expectant mothers had statistically significant association with ID warranting further investigation.

Despite these positive results it was found that 16% of children and 12% of mothers had mild, moderate or severe ID. While the progress over a relatively short period has been substantial there is a need for reinforcement of the iodine supplementation program as the aim is to ensure its continued success.

## **Introduction**

The human body needs only one teaspoon of the essential trace element iodine over its life. It is a critical component of the thyroid hormones, thyroxine ( $T_3$ ) and tri-iodothyronine ( $T_4$ ) which play important roles in differentiation, growth, and development **(1)**.

Iodine deficiency affects all the three development stages of human life. During pregnancy (fetal development), it can cause spontaneous abortions, stillbirths, increase in perinatal mortality, congenital abnormalities, neurological cretinism, fetal hypothyroidism and psychomotor defects **(1)**. In adolescents, iodine deficiency can result in subclinical hypothyroidism, hypothyroidism developing into goiter, mental retardation, and retarded development with myxedematous or neurological cretinism being present as well **(1)**. In adults, this deficiency manifests as endemic goiter. All of these disorders combined at the population level are termed Iodine Deficiency Disorders (IDD) **(2)**.

It is estimated that 1571 million people worldwide are at risk of developing iodine deficiency **(3)**. Furthermore 28 million children born every year are at some risk of mental retardation due to iodine deficiency in their mother's diet **(3)**. When compared to people in iodine sufficient areas, people in regions affected by iodine deficiency have been found to have a lower IQ at times as much as 13.5 points lower **(4)**. This affects the learning capacity of children as well as the quality of life for the communities and in the long run, economic productivity.

Iodine deficiency is thought to be the single most preventable cause of mental retardation.

In 1994, a study discovered a high prevalence of goiter with very low urinary iodine (UI) levels in Fiji **(5)**. To eliminate iodine deficiency, legislation was implemented in Fiji for the exclusive importation of sufficiently iodized salts, ensuring that only iodized salt would be available.

According to the International Council for Control of Iodine Deficiency Disorders (ICCIDD) successful elimination of iodine deficiency requires three components: political support, administrative arrangements, assessment and monitoring **(6)**.

- (i) Political support is important for passage of laws or regulations for salt iodization
- (ii) Administrative arrangement, namely a national body responsible for management of iodine deficiency control program. The body should operate with a process model which emphasizes the multi-sectoral collaboration/ coordination/ contribution that are needed to eliminate iodine deficiency.
- (iii) Assessment and monitoring is basically the measuring of salt iodine and urinary iodine at regular intervals to ensure iodine deficiency has been eliminated.

This study attempted to evaluate the success of Fiji's salt iodization program that was introduced in 1996 to eliminating iodine deficiency. This was done by determining whether there was still a prevalence of iodine deficiency in children (8-12 years of age) as well as in pregnant women. The criteria utilized to measure the success of programs for iodine deficiency elimination is that less than 50% of the population should have urinary iodine levels below 100  $\mu\text{g/L}$  and less than 20% of the population's urinary iodine levels should be below 50  $\mu\text{g/L}$  (3). This study determined these proportions for Fiji as well as identifying whether certain foods and attitudes of expectant mothers towards importance of iodine, might be playing a role.

### **Materials and Methods**

This study was directed by Fiji's Ministry of Health which instructed to include all the schools from the first iodine study in 1994. In addition to these schools the current study included schools and antenatal clinic from the fourth sentinel district, Labasa. Apart from this directive of the Ministry of Health no funding organization had a role in the design, data collection, analysis interpretation, or preparation and publication of this manuscript

#### *Sample collection*

Urine and salt samples were collected and tested for iodine levels.

### *Urine*

Due to costs involved in large scale cross sectional surveys such as was used in this project the accepted and more practical Sentinel surveillance method was utilized to collect samples (6). Districts were chosen on the basis of whether they had been established to have moderate or severe ID before the implementation of salt iodization (6). The sentinel districts were Suva, Sigatoka (Valley), Ba and Labasa. 5mL of urine samples were collected from 18 schools and 4 major antenatal clinics. The antenatal participants were also required to complete a questionnaire. The questionnaire attempted to determine the amount of iodine and goitrogens in the diet, the students were asked if they were aware of the importance of iodine or not.

### *Salt*

The school children also provided a spoonful of salt that was used in their home. Iodine analysis

### *Urinary Iodine analysis*

The urine samples were collected from participants and assessed for iodine levels at the Endocrinology Laboratory at Westmead Hospital, Australia using a spectrophotometric procedure based on the Sandell- Kolthoff reaction (6).

### *Salt Iodine analysis*

The salt samples provided by the students were analyzed for iodine content using the MBIKITS provided by the UNICEF office in Suva, Fiji.

### *Statistical analysis*

EpiInfo statistical software was used for both; data entry and data analysis. Median urinary iodine concentrations (MUIC) were calculated in accordance with WHO recommendations for population studies. Pearson's chi-square tested for association between Iodine Deficiency (ID) and various other factors. Odds ratio

measured the magnitude of association between Iodine Deficiency and the other factors. All were considered significant if  $p < 0.05$ .

### *Ethical Approval*

Permission was gained from the Fiji National Research Committee and Ethical approval was gained from Charles Sturt University ethics committee

### **Results**

A total of 1375 urine samples were collected of which 310 were antenatal and 1065 were from school children. Due to labeling errors 979 of the school childrens urine samples and 292 of the antenatal urine samples could be used. A total of 883 samples of salt were received for iodine testing.

Over 80% of the sample population did not have iodine deficiency (Figure 1). As mentioned previously success in elimination of iodine deficiency is identified when less than 50% of the population has urinary iodine levels below  $100\mu\text{g/L}$  and less than 20% of the population's urinary iodine levels are below  $50\mu\text{g/L}$ . This was true for the overall sample population (Table 1) as well as the 4 different districts (Table 2)

The gender distribution for school children was approximately even with the female to male ratio being 53:47. Iodine deficiency cases were 1.5 times more likely to be females than males (chi-square = 12.05, p-value = 0.01 and the odds ratio = 1.49 with 95% confidence interval of 1.05(lower), 2.10(upper)).

The samples from children comprised of 71.9% Fijians, 25.9% Indo-Fijians, and 2.2% other ethnicities. The distribution of the cases of iodine deficiency was homogeneous among the different ethnic groups (p-value = 0.19).

78.6% of the 1065 students did not know if iodine was important or not; 12.7% stated that iodine was not important and 8.7% stated iodine was important for health.

*Iodine in Salt*

98.4% of the salt samples tested had levels of iodine above 15ppm while the remaining 1.6% had less than 15ppm. No statistical relationship was found (chi-square test = 0.18, p-value = 0.68) between salt iodization status and iodine deficiency.

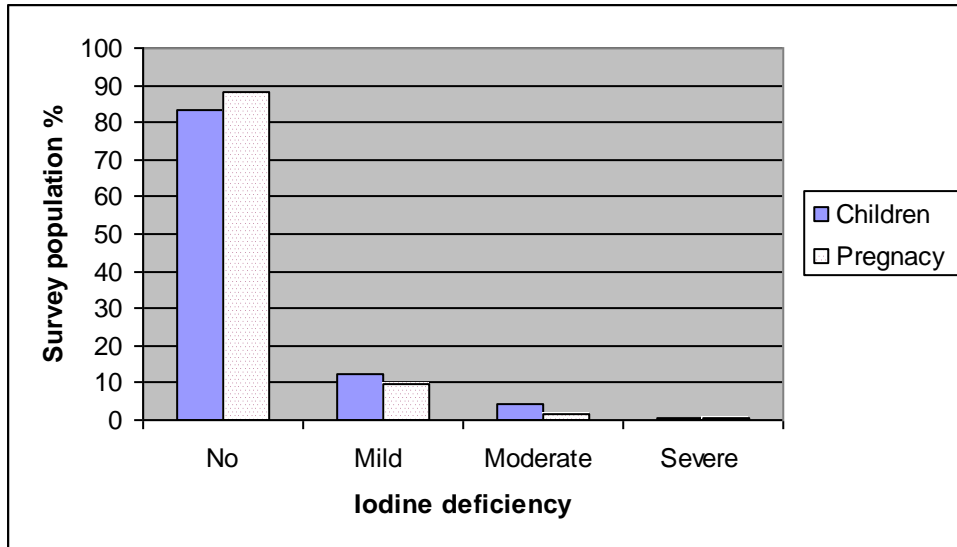


Figure 1 Amount of iodine deficiency in sample of Fiji school children and expectant mothers. The criteria for classification: Severe iodine deficiency: UI < 20µg/L; Moderate iodine deficiency UI was between 20-49µg/L; mild iodine deficiency UI was between 50-99µg/L (6)

Table 1 Urinary Iodine Levels of Children and Mothers. 50% of the population had urinary iodine above 100ug/L and less than 20% of the population's urinary iodine levels were below 50µg/L

	20 <sup>th</sup> percentile	Median
Target UI levels	50 ug/L	100 ug/L
Children's Urine iodine level	112 ug/L	237 ug/L
Mother's Urine iodine level	127 ug/L	227 ug/L

Table 2 Urinary Iodine levels separated into four sentinel districts: in all districts 50% of the population had urinary iodine levels above 100ug/L and less than 20% of the population's urinary iodine levels were below 50µg/L

	Districts			
	Ba	Labasa	Sigatoka	Suva
<b>Children</b>				
Median	224 ug/L	207 ug/L	246 ug/L	237 ug/L
20 <sup>th</sup> percentile	86 ug/L	95 ug/L	123 ug/L	117 ug/L
<b>Pregnancy</b>				
Median	261 ug/L	251 ug/L	204 ug/L	225 ug/L
20 <sup>th</sup> percentile	139 ug/L	162 ug/L	114 ug/L	115 ug/L

*The Relationship between pregnancy diet and iodine deficiency*

This part of the study the study attempted to determine whether there were any associations between 39 food items (goitrogens, iodine rich foods, drinks and meat) and iodine levels (Table 3 Appendix). It was found that only consumption of maize flour (p=0.018) and soy milk (p=0.037) had a significant association with iodine deficiency. Those with iodine deficiency were 2.5 times more likely to have been consuming Maize flour compared to those without iodine deficiency (OR = 0.52; CI = 0.35). Those with iodine deficiency were 6.15 times more likely to have been consuming soy milk compared to those without iodine deficiency (OR = 0.395; CI = 0.37).

*Relationship between medical history and iodine deficiency*

The incidence of abortions, miscarriages and stillbirth data was obtained from the volunteer history. There was no statistically significant association between iodine deficiency and abortion, miscarriages, and still births. Information on participants' family history of goiter and other IDD was provided by the participants' as there was no access to their families medical history. No association between iodine deficiency and the participants' family history of goiter and other IDD was found. Furthermore salt storage variations such as exposure

to sun, type of storage container or the type of water consumed did not have a statistically significant association with iodine deficiency.

## **Discussion**

This was the first follow up study to evaluate the effect of a salt iodization in Fiji which commenced in 1996. A total of 1279 urine iodine results revealed that the salt iodization program had been a success in Sigatoka, Ba, Suva, and Labasa.

Of all the dietary items listed in the food frequency questionnaire only maize flour and soy milk had a significant association with iodine deficiency. Maize contains cyanogenic glucosides which are known goitrogens (7). Milk is a source of iodine because of the iodine based sanitizers used in the dairy industry. It is possible that mothers who consume soy milk do not consume dairy milk therefore the association between soy milk and iodine deficiency. Soy is also believed to be a goitrogen which could another reason for this association (7).

In this study 16.4% of children and 11.6% of mothers had some form of iodine deficiency compared to a recent study in mainland Australia reported that 46.3% of the children tested had iodine deficiency (8). It was also reported there national UI median as 104ug/L while NSW and Victoria had a median UI of 89ug/L and 73.5ug/L. Similar results during pregnancy in Australia have been reported (9). A 2005 study in New Zealand discovered that breastfeeding mothers had low levels iodine (10), while New Zealand's National Children's Nutrition survey reported 28% of New Zealand children had low levels of iodine (11). In contrast to these, in Fiji the medians were above a 100ug/L.

It appears that Fiji has been more successful in eliminating iodine deficiency compared to its neighboring countries. A few years ago Australia was iodine sufficient and only recently it was discovered that iodine deficiency had resurfaced (12).

Reemergence of iodine deficiency is common where the third component that is the assessment and monitoring system described by the ICCID is not in place. Table 4 illustrates the status of Fiji regarding the criteria for monitoring progress against IDD and indicators.

Discussions on the preliminary results of this survey with the Ministry of Health resulted in invigorated commitment especially for the programmatic indicators **(6)** ensuring the goal of 8 of the 10 indicators was met.

The first programmatic indicator was the establishment of an “effective functional national body”. In Fiji the National Micronutrient Fortification Committee had been made responsible for iodine, iron and vitamin A. The second indicator was evidence of political commitment to universal salt iodization and elimination of IDD. There has been legislation in place since 1996 to ensure only iodized salt was available in Fiji. The Chief Dietitian of Fiji has been appointed as the officer responsible for the iodine deficiency program thereby fulfilling the third programmatic indicator. As mentioned previously legislation making uniodized salt illegal in Fiji is in place thus ensuring Fiji met the fourth programmatic indicator.

The fifth indicator, is commitment to assessment and reassessment, with access to laboratory facilities. Fiji School of Medicine has been established as center of urinary iodine analysis with funding by UNICEF thus providing an inexpensive opportunity to evaluate the success of its elimination of iodine deficiency plan at regular intervals. In addition funds have been made available for regular monitoring of UI. There is no program of public education which is the sixth programmatic indicator. As legislation had been put in place, it was believed that a major public campaign was not deemed necessary especially with Fiji’s escalating rate of Non Communicable Diseases and the role excess salt plays. The next programmatic indicator is the availability of regular data on salt iodine at factory, retail, and household levels. This data is to be collected by health officers from factories to ensure salt has been iodized adequately.

According to the eighth programmatic indicator, regular laboratory data on UI in school age children should be available. Following this survey there has been commitment by the Ministry of Health for regular assessments of UI thus ensuring that data on school age children increases. The ninth programmatic indicator was cooperation from salt industry in maintenance of quality control. As of April/May 2007, all importers requesting for approvals for imports of their

consignments are to provide the analysis report as well as samples for assessment by Ministry of Health. The final programmatic indicator was data base for recording of results (SI, UI) with public reporting. This was designed by Fiji School of Medicine during the current study and should be expended upon.

Table 4 Fiji's status of criteria for monitoring progress against IDD

Status	Goals	Achieved or Not
Proportion of households using adequate iodized salt	>90%	Yes
Urinary Iodine concentration	Median > 100 ug/L	Yes
	20th percentile > 50 ug/L	Yes
Programmatic indicators	Attainment of at least 8 out of the 10	Yes (9/10)

Population urinary iodine levels and programmatic indicators revealed that iodine deficiency disorders should no longer be a problem for Fiji. When considering the programmatic indicators carefully they have only recently been met. It is essential that the national body works effectively to ensure sustainable elimination of iodine deficiency. It is crucial that the national body monitors urinary iodine levels at regular two yearly intervals to ensure there is no reemergence of ID as has been the case in Australia and New Zealand.

### **Acknowledgments**

This work was supported by grants from UNICEF and WHO. We would like to thank the Fiji Public Service Commission and the Ministry of Education for allowing this study to be conducted in the selected schools. The authors would like to thank all the Heads of schools and teachers, parents, and the students for assisting and participating in this study. The authors acknowledge the support of the Ministry of Health especially the divisional directors for the release of their staff who assisted with sample collection.

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## Appendix

Table 3 Diet and Iodine deficiency

Question Food item	Answer serves month	IDD		P- value	OR	
		Yes	No		Point Estimate	95% CI
		%	%			
Normal Whet Flour	0-12	41.2	29.5	0.417		
	13-28	20.6	31.8			
	29-56	23.5	20.9			
	57-420	14.7	17.8			
Bread	0-4	26.5	28.3	0.904		
	5-12	32.5	30.1			
	13-28	14.7	18.5			
	29-448	26.5	23.3			
Oats/Porridge	0	35.3	34.1	0.176		
	1-4	17.6	30.2			
	5-8	23.5	11.6			
	9-112	23.5	24.0			
Maize Flour *	0	67.6	84.1	0.018	0.395	(0.17,0.87)
	0.3-84	32.4	15.9			
Canola Oil	0	79.4	86.0	0.304	0.626	(0.25,1.54)
	0.3-840	20.6	14.0			
Soya bean oil	0-16	32.4	24.1	0.603		
	17-84	35.3	40.1			
	85-112	5.9	11.3			
	113-1400	26.5	24.5			
<b>Meat</b>						
Red Meat	0-4	41.2	48.4	0.416		
	5-8	32.4	20.5			
	9-12	8.8	14.0			
	13-84	17.6	17.1			
White meat	0-4	32.4	46.1	0.197		
	5-8	26.5	26.7			
	9-12	29.4	15.5			
	13-84	11.8	11.6			
<b>Seafood</b>						
Sea food Fresh water	0	44.1	37.6	0.739		
	0.3-2	11.8	14.7			
	3-8	29.4	26.4			
	9-56	14.7	21.3			
Sea food Sea water	0-1	20.6	20.6	0.235		
	1-4	32.4	39.5			
	5-8	11.8	19.4			
	9-168	35.3	20.6			

Seaweed	0 0.3-56	67.6 32.4	61.6 38.4	0.496	1.302	(0.61,2.79)
Question Food item	Answer serves month	IDD		P- value	OR	
		Yes	No		Point Estimate	95% CI
		%	%			
Eggs	0-2 3-8 9-24 25-196	26.5 47.1 8.8 17.6	22.1 37.2 19.0 21.7	0.393		
<b>Dairy products</b>						
Liquid Milk	0 0.3-28 29-168	41.2 44.1 14.7	41.5 38.8 19.8	0.733		
Fresh cows milk	0 1-168	85.3 14.7	87.6 12.4	0.437	0.704	(0.30,2.27)
Powdered milk	0 0.3-16 17-28 29-196	44.1 14.7 14.7 26.5	33.7 16.3 27.1 22.9	0.400		
Soy Milk*	0 0.3-28	91.2 8.8	98.4 1.6	0.037	0.163	(0.03,0.76)
Other Dairy products	0 0.3-4 5-8 9-84	33.3 33.3 12.1 21.2	25.6 38.8 14.7 20.9	0.794		
Food containing red dye	0 0.3-112	64.7 35.3	50.4 49.6	0.116	1.805	(0.86,3.80)
<b>Vegetables</b>						
Cassava	0-4 5-12 13-28 29-224	38.2 11.8 26.5 23.5	35.3 20.2 22.1 22.5	0.695		
Sweet potatoes	0 0.3-112	55.9 44.1	50.0 50.0	0.519	1.267	(0.62,2.60)
Cabbage (English)	0-4 5-168	52.9 47.1	55.0 45.0	0.817	0.919	(0.45,1.88)
Cabbage (Chinese)	0-4 5-168	52.9 47.1	55.6 44.4	0.766	0.897	(0.43,1.83)
Churaiya/Tumbua	0-4 5-112	52.9 47.1	47.9 52.1	0.577	1.226	(0.60,2.51)
Bele	0-2 3-4 5-12 13-224	17.6 23.5 38.2 20.6	26.4 30.2 20.9 22.5	0.149		
Dalo leaves (RouRou)	0-0.6 1-4	14.7 41.2	25.9 38.4	0.292		

	5-8 9-84	26.5 17.6	15.7 20.0			
Question Food item	Answer serves month	IDD		P- value	OR	
		Yes	No		Point Estimate	95% CI
		%	%			
Ota	0 0.3-56	52.9 47.1	59.5 40.5	0.463	0.765	(0.37,1.57)
Karamua	0 0.3-112	67.6 32.4	66.1 33.9	0.862	1.070	(0.50,2.30)
Cauliflower	0 0.3-28	70.6 29.4	73.6 26.4	0.705	0.859	(0.39,1.89)
Legumes	0-4 5-8 9-12 13-84	58.8 17.6 14.7 8.8	48.4 18.6 11.6 21.3	0.352		
Maize	0 0.3-28	58.8 41.2	45.7 54.3	0.151	1.695	(0.82,3.50)
Peanuts	0-1 2-4 5-112	41.2 35.3 23.5	35.3 37.6 27.1	0.787		
Local Fruits	0-12 13-28 29-336	44.1 38.2 17.6	32.7 43.2 24.1	0.393		
Imported Fruits	0-2 3-13 13-140	32.4 38.2 29.4	33.3 34.1 32.6	0.883		
<b>Drinks</b>						
Home made fruit juice	0-0.3 0.6-20 21-140	29.4 41.2 29.4	35.2 30.8 34.0	0.478		
Pure fruit juice	0 0.3-224	85.3 14.7	85.3 14.7	0.997	1.00	(0.37,2.74)
Fruit concentrates	0 0.3-140	67.6 32.4	57.8 42.2	0.270	1.530	(0.72,3.27)
Fizzy drinks	0 0.3-56	65.7 35.3	57.4 42.6	0.415	1.363	(0.65,2.87)
Coffee	0 0.3-56	91.2 8.8	81.4 18.6	0.158	2.362	(0.69,8.05)
Meat substitutes	0 0.3-12	88.2 11.8	92.9 7.1	0.252	0.572	(0.18,1.80)