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ABSTRACT:

Insufficient intake of iodine or consumption of foods containing goitrogens can decrease thyroid function leading to multiple physical and mental disorders known collectively as iodine deficiency disorders. Successful implementation of the universal salt iodization strategy, which is the main intervention strategy for the control and elimination of iodine deficiency, requires constant monitoring. Urinary iodine concentration is the recommended biochemical indicator for assessing the iodine status of a population. The present studies were prompted by the apparent lack of published data on the status of iodine nutrition among school-age children in Morobe and Eastern Highlands provinces in Papua New Guinea (PNG). The aims of these studies were to determine the urinary iodine concentration in school-age children (6 – 12 years) as a way of assessing the impact of the salt iodization programs in Morobe and Eastern Highlands Provinces in PNG. These prospective school based cross-sectional studies were carried out in Aseki-Menyamya district Morobe province and Gouno, Mt. Michael Local-Level Government area in Lufa district Eastern Highlands province, PNG. Simple random sampling was used to select primary schools in each district. The iodine content in salt samples was measured using the single wavelength semi-automated WYD Iodine Checker Photometer. Urinary iodine concentration (UIC) was estimated using the Sandell-Kolthoff reaction. In Lufa district, the mean per capita discretionary consumption of salt was 4.7 ± 2.1g per day with a range of 2.1 – 9.6g; the mean iodine content in salt samples from the households was 17.8 ± 4.5ppm; the iodine content was below 15ppm in 23.8% of all the salt samples. For the children in Aseki-Menyamya district, the median UIC was 149.5µg/L, Interquartile Range (IQR) was 70.0 – 300µg/L; the UIC was below 100.0µg/L in 32.9% of the children and 17.9% had UIC below 50µg/L. For children in Gouno Lufa district, the median UIC was 50.0µg/L, IQR was 23.9 – 76.0µg/L, 87.9% had UIC below 100.0µg/L, and 49.2% had UIC below 50.0µg/L. The results indicate that iodine deficiency should be considered a significant public health problem among the school-age children in Gouno Lufa district. Our findings indicate the urgent need for efficient, sustainable, systematic and functional monitoring system to strengthen and improve on the implementation of the USI strategy in both districts.

KEYWORDS: Iodized salt, Urinary Iodine, Iodine deficiency, Menyamya, Lufa, PNG.

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INTRODUCTION:

Bioavailability of adequate amount of iodine is one of the prerequisites for biosynthesis of the thyroid hormones, which are essential for normal metabolism, growth and development [1 – 2]. Insufficient intake of iodine or consumption of foods containing goitrogens can decrease thyroid function leading to multiple physical and mental disorders known collectively as iodine deficiency disorders (IDD) [1 – 3]. The expression and extent of these disorders are dependent on the severity and timing of iodine deficiency [1, 3].

Iodine deficiency (ID) is regarded, as the single most common cause of preventable mental impairment in communities with suboptimal intake of iodine [1 – 3]. Currently, the prevalent forms of IDD in most resource limited countries are the more subtle degrees of mental impairment that occur in apparently healthy children with low intake of iodine [1 – 5]. The manifestations include poor performance in school and in psychometric tests, reduced intellectual ability and impaired motor functions. Among the several strategies for reducing the prevalence of IDD, universal salt iodization (USI), a policy of iodizing all salt for human consumption, is recommended for the control and elimination of IDD in affected populations [1, 2, 5 – 7]. Effective implementation of the USI strategy requires continuous monitoring of the process, impact and sustainable indicators in the affected communities [1, 2, 5 – 7]. The recommended principal impact indicator of USI is the assessment of Urinary Iodine Concentration (UIC) among school-age children in the target population [1, 3, 7].

In an attempt to control IDD, and to comply with the international goal of USI, the Government of Papua New Guinea (PNG) amended the pure food standards (PFS) by promulgating the salt legislation in June 1995, banning the importation and sale of non-iodized salt in the country [8]. According to the amended PFS, all salt imported into the country must be iodized with Potassium Iodate, and the iodine content should not be less than 30ppm; in addition, all salt must be packaged in waterproof containers to minimize the loss of iodine [8, 12, 15]. The PNG National Executive Council (NEC) endorsed the implementation of the amended PFS as the PNG Food Sanitation Regulation (PNGFSR) in February 2007 [15].

One of the major issues in some resource limited countries, like PNG, is the long-term sustainability of salt iodization programs, which require constant monitoring of the iodine status of the population [1, 2, 7]. Lack of monitoring can lead to regression in achievements of IDD control programs. In addition, poorly monitored programs can cause excessive intake of dietary iodine, which may be associated with risks of adverse health consequences, such as, Iodine-Induced Hyperthyroidism (IIH) [1,7,9]. Some recent reports [10, 11] indicated growing evidence that iodine deficiency may be reappearing in some countries where it was previously under control. This statement further underscores the need for continuous monitoring and evaluation of the iodine status of populations that have been at risk of IDD in the past. Thus, the need for evaluating the implementation of the USI strategy in PNG cannot be overemphasized.

According to Amoa et al [12] endemic goiter was prevalent in specific isolated areas in PNG, despite the availability of iodized salt. In Menyamya district Morobe province the incidence of goiter in 1997 was 14% among the schoolchildren surveyed [12]. Results of a study that assessed the UIC among school-age children (6 – 12 years) in Hella district Southern Highlands Province (SHP) PNG indicated that, despite the apparent success of the salt iodization program, there was high prevalence of iodine deficiency among the male and female children [13, 14]. Reports from the PNG National Nutrition Survey carried out in 2005 (PNG NNS 2005) indicated adequate status of iodine nutrition among non-pregnant women of child-bearing age in the four regions of PNG [15]. However, the PNG NNS 2005 did not provide data on the iodine status in the various Provinces and Districts in PNG [15]. Recent data indicated that despite some success in the implementation of the USI strategy in PNG, there is prevalence of mild to moderate status of iodine deficiency among school-age children, pregnant women, lactating women and women of childbearing age in some areas in PNG [13, 16 – 18]. A search of the literature indicates scanty information on the salt iodization program for control of IDD in Morobe [12, 15] and Eastern Highlands [16] provinces. In addition, no published data is available on the assessment of the principal impact indicator of USI in both provinces. The present studies were prompted by the apparent lack of published data on the status of iodine nutrition among school-age children in Morobe and Eastern Highlands provinces in PNG. Thus, the aims of the current studies were to determine the urinary iodine concentrations (UIC) in school-age children (6 – 12 years) as a way of assessing the impact of the salt iodization programs in Morobe and Eastern Highlands Provinces in PNG.

SUBJECTS AND METHODS:

These prospective school-based cross-sectional studies were carried out in Aseki-Menyamya district Morobe province and Gouno, Mt. Michael Local-Level

Government (LLG) area in Lufa district Eastern Highlands province (EHP), PNG. EHP is one of the five Highlands Provinces [19]. It shares provincial boundaries with Morobe, Madang, Gulf and Chimbu provinces. Menyamya and Lufa districts are located at altitudes of about 1100 meters and 1800 meters respectively [19].

The study population consisted of Schoolchildren in the age group 6 – 12 years. Simple random sampling was used to select the primary schools in each district. The total enrolments for each of the randomly selected primary schools, including the ages of children in each of the grades were listed. All children below 6 years of age and above 12 years of age were identified and excluded from the studies.

Calculation of sample size was based on a design effect of three, a relative precision of 10% and confidence level (CL) of 95%. As there was very limited information on likely prevalence rates of IDD in Aseki-Menyamya and Gouno Lufa districts, an assumed prevalence rate of 25% was used for each province. With a predicted non-response rate of 10%, the sample sizes of 200 and 150 school-age children were obtained for Aseki-Menyamya and Gouno Lufa districts respectively. These numbers were higher than the 50 recommended by the WHO/UNICEF/ICCIDD expert committee for school-based studies on the prevalence of IDD in affected populations [1].

For a given school, each of the children in the 6 – 12 years age group was assigned a computer-generated random number. The required number of children from each school was then selected by simple random sampling using the randomly generated number list. In Gouno Lufa district two cohorts of children were selected using separate randomly generated number lists. Those in the first cohort, 42 children, were involved in the assessment of the discretionary use of iodized salt including the availability of iodized salt in the households. This study was not carried out in Aseki-Menyamya district because of logistical reasons. Each of the 42 selected households in Gouno Lufa district was visited twice. Signed informed consent was obtained from the head of the household during the first visit; in addition, the total number of residents that eat food prepared in the household was recorded. One teaspoon (about 5.0g) of the salt available in the household was collected and stored in an airtight zip-lock plastic bag for analysis. A pre-weighed (250.0g) package of iodized salt was given to the head of the household to use for food preparation and consumption as usual. Each household was revisited three days later. The salt remaining in the package was reweighed to the nearest 0.1g. The total amount of salt consumed was calculated and considered as the discretionary salt intake.

Salt samples were purchased from randomly selected trade and retail shops in Aseki- Menyamya and Gouno Lufa districts for analysis of their iodine content. A self-designed, pre-tested questionnaire was used to assess the knowledge and use of iodized salt in households in both districts. The head of each selected household was requested to complete the questionnaire.

On the spot urine sample was collected from each of the consented schoolchildren in the selected schools in Aseki-Menyamya district and the second cohort of children in Gouno Lufa district. Each urine sample was stored in properly labeled plastic tube with tight fitting stopper that was further sealed with special plastic band. The urine and salt samples were then appropriately packed separately and transported by airfreight to the Micronutrient Research Laboratory (MRL) in the School of Medicine and Health Sciences (SMHS) University of Papua New Guinea (UPNG). The samples were stored in separate refrigerators till required for analyses.

The iodine content in the salt samples from the households and stores was measured using the WYD Iodine Checker [20]. The Sandell-Kolthoff reaction was used for the assay of urinary iodine (UI) after digesting the urine with Ammonium Persulfate in water–bath at 100°C [1]. Internal bench quality control (QC) characterization of the assay methods for UI and salt samples were by the Levy-Jennings Charts and the Westgard Rules. External QC monitoring of the UI assay procedure was by “Ensuring the Quality of Urinary Iodine Procedures” (EQUIP), which is the External Quality Assurance Program (QAP) of the Centers for Disease Control and Prevention (CDC), Atlanta, Georgia, USA.

Microsoft Excel Data Pack 2007 and the Statistical Package for Social Sciences (SPSS) software (version 15) were used for statistical analyses of the data. Kolmogorov-Smirnov test was used to assess normality of the data. Mann Whitney U test was used for differences between two groups; Kruskal-Wallis and Friedman were used for comparison of all groups. Analysis of variance (ANOVA) was also used to compare differences between groups. Scheffe test was used for post-hoc analysis. $P < 0.05$ was considered as statistically significant.

The data were interpreted using the current WHO/UNICEF/ICCIDD criteria [1 – 3, 7, 9]. Appropriate implementation of the USI strategy was assumed if at least 90.0% of households were using salt with iodine content of 15.0ppm or more. Iodine deficiency was considered as a public health problem in the target population if the Median UIC was below 100.0µg/L and more than 20% of the children have UIC below 50.0µg/L. Specific cut-off points for UIC were used for classifying the Status of Iodine Nutrition into different degrees of public health significance [1 – 3, 7, 9]. Further interpretation of the iodine content in salt samples was carried out using the 30ppm cutoff value proposed by the PNG Food Sanitation Regulation (PNGFSR) [8, 15]. Ethical clearance and permission for these studies were obtained from the Ethics and Research Grant committee in the SMHS UPNG. Permissions were obtained from the appropriate authorities in Menyamya and Lufa districts, and also from the Headmasters / Headmistresses in the various primary schools. Parental consent and approval were obtained from parents / Guardians of the selected children. The verbal approval of each child with parental consent was also obtained at the time of urine collection.

RESULTS:

The mean per capita discretionary consumption of salt in Lufa district was 4.7 ± 2.1g per day (Mean ± Standard Deviation), with a median of 4.2g and range of 2.1 – 9.6g. Salt was available in all the 42 households visited. The mean iodine content in salt samples from the households was 17.8 ± 4.5ppm, median was 18.5ppm and range was 7.4 – 24.4ppm. Although the iodine content was below 15ppm in 23.8% of all the salt samples, 97.6% of the salt samples had iodine content below 30ppm. Only four brands of salt were available in Gouno, Lufa district. The iodine content was greater than 15ppm in all the four brands, but two (50%) of the four brands had iodine content below 30ppm.

A total of 12 salt packages, made up of three “traditional” salt and nine different brands of salt, were purchased from randomly selected stores in Aseki-Menyamya district. The iodine content in each of the three traditional salt samples was below 15ppm; the values were 9.9ppm, 11.4ppm and 14.0ppm. The iodine content was greater than 15ppm in all the nine brands of salt. However, the iodine content in two (22.2%) of the nine brands of salt was below 30ppm. The mean iodine content in all the nine brands of salt was 49.8 ± 17.5ppm, the median was 56.2ppm and the range was 28.9 – 77.7ppm.

A total of 124 and 42 questionnaires were distributed in Aseki-Menyamya and Gouno Lufa districts respectively. All the respondents in Aseki-Menyamya completed their questionnaires, compared to 90.5% respondents in Gouno Lufa district. Analysis of the questionnaires indicated that salt was used regularly by 99.2% and 100% households in Aseki-Menyamya and Gouno Lufa districts respectively. A total of 87.0% of all the respondents in Gouno Lufa had never heard about iodized salt compared to

53.6% in Asemi-Menyamya that were told about iodized salt by friends and relatives. Among respondents in Aseki-Menyamya, 65.0% were sure of using iodized salt at home compared to 96.0% in Gouno Lufa that were not sure of using iodized salt at home. A total of 85.5% of all the respondents in Aseki-Menyamya did not know about the importance of iodized salt compared to 92.0% in Gouno Lufa. Salt was purchased from supermarkets and local markets by 60.2% and 39.8.0% of respondents in Aseki-Menyamya compared to 82.0% and 18.0% of respondents in Gouno Lufa respectively. No particular brand or type of salt was popular among respondents in Aseki-Menyamya and Gouno Lufa because the price of the available salt was the determining factor for them. However, 15% of respondents in Aseki-Menyamya use traditional salt for preparation of some local dishes. Salt was kept in closed plastic containers by 82.9% of respondents in Aseki-Menyamya compared to 74.0% in Gouno Lufa that kept salt in open plastic containers. When asked about frequency of consumption of sea-food, among respondents in Aseki-Menyamya 56.5% had never eaten sea-food, 30.6% said once in a while and 12.9% did not remember. Among respondents in Gouno Lufa 55.0% said once in a while and 45.0% said never.

A total of 222 and 135 schoolchildren in Aseki-Menyamya and in Gouno Lufa district respectively were enrolled for the studies. Informed consents to participate in the study were obtained from 207 and 132 parents in Aseki-Menyamya and Gouno Lufa respectively. Thus, the response rates were 93.2% and 97.8% in Aseki-Menyamya and Gouno Lufa districts. The Kolmogorov-Smirnov test for normality indicated that the frequency distribution curves of the UIC for all the children in Aseki-Menyamya and Gouno Lufa were not normally distributed. Thus, non-parametric statistics was used for analysis of the UIC data.

The summary statistics of the UIC for the children are presented in Table 1. For all the children in Aseki-Menyamya the median UIC was 149.5µg/L and Interquartile Range (IQR) was 70.0 – 300µg/L. The UIC was below 100.0µg/L in 32.9% of all the children and 17.9% had UIC below 50µg/L. For the children in Gouno Lufa the median UIC was 50.0µg/L, IQR was 23.9 – 76.0µg/L, UIC was below 100.0µg/L in 87.9% of them and 49.2% had UIC below 50.0µg/L. Using the Mann-Whitney and Wilcoxon tests, the UIC for children in Aseki-Menyamya was significantly higher ($p < 0.01$) than the UIC for those in Gouno Lufa; similar results were obtained using the Kruskal Wallis and Chi-Square tests ($p < 0.01$).

Distribution of the children according to the range of UIC and status of iodine nutrition is presented in Table 2. Severe, Moderate and Mild status of iodine nutrition were prevalent in 8.2%, 9.7% and 15.0% of all the children in Aseki-Menyamya respectively, compared to 17.4%, 31.8% and 38.6% of all the children in Gouno Lufa respectively. According to current WHO/ICCIDD/WHO criteria [1, 9], severe to mild status of iodine nutrition was prevalent in 32.9% and 87.8% of the children in Aseki-Menyamya and Gouno Lufa districts respectively. Thus, iodine deficiency should be considered as public health problem among schoolchildren, age 6 – 12 years, in both districts. The situation however, was more severe in Gouno Lufa district compared to Aseki-Menyamya district at the time of these studies.

No statistically significant correlation was obtained when the UIC for children in Aseki-Menyamya and Gouno Lufa were compared with responses in the respective questionnaires.

Table 1: Summary statistics of Urinary Iodine concentration (UIC) (µg/L) for school-age children (6 – 12 years)

Parameters	**Aseki-Menyamya**	**Gouno Lufa**
N	207	132
Median (µg/L)	149.5	50.0
Interquartile range (IQR) (µg/L)	70.0 – 300.0	23.9 – 76.0
Mean (µg/L)	207.6	57.3
Standard Deviation	177.2	40.1
95% Confidence Interval (p = 0.05)	183.3 – 231.9	50.4 – 64.2
% (n) of children with UIC below 100µg/L	32.9 (68)	87.9 (116)
% (n) of children with UIC below 50µg/L	17.9 (37)	49.2 (65)

Table 2: Distribution of the children according to range of urinary iodine concentration (UIC) (µg/L) and status of iodine nutrition

Range of UIC (µg/L)	Status of Iodine Nutrition	Percent (n) distribution of children	
		Aseki-Menyamya (n = 207)	Gouno Lufa (n = 132)
< 20	Severe	8.2% (17)	17.4% (23)
20 – 49	Moderate	9.7% (20)	31.8% (42)
50 – 99	Mild	15.0% (31)	38.6% (51)
100 – 199	Optimal	29.0% (60)	11.4% (15)
200 – 299	Risk of IIH*	12.6% (26)	0.8% (1)
≥300	Risk of adverse health	25.6% (53)	0

*IIH: Iodine Induced Hyperthyroidism

For detailed analysis of the UIC data the children were separated according to age groups. The summary statistics of the UIC for children in the various age groups in Aseki-Menyamya and Gouno Lufa are presented in Table 3.

No statistically significant differences were indicated when the UIC for the children in the various age groups in Aseki-Menyamya were compared using the Mann-Whitney and Wilcoxon tests ($p > 0.05$) and the Kruskal Wallis tests ($p > 0.05$).

Similar results were obtained when the UIC for children in the various age groups in Gouno Lufa were compared. However, the UIC for children in the various age groups in Aseki-Menyamya were significant higher ($p< 0.05$) than the UIC for their counterparts in Gouno Lufa.

Unlike the children in Aseki-Menyamya, the median UIC for the children in all the age groups in Gouno Lufa were below 100.0µg/L (Fig. 1), indicating suboptimal status of iodine nutrition for all of them. Table 4 shows the percent distribution of the children in the various age groups according to the range of UIC and status of iodine nutrition. In Gouno Lufa, prevalence of severe status of iodine nutrition was highest among the children in the youngest age group (6years); followed by moderate status that was highest among children in the 7years age group and mild status highest among children in the 10years age group. Severe to mild status of iodine nutrition was prevalent among children in all the age groups in Gouno Lufa compared to Aseki-Menyamya.

For further analysis, the UIC data was separated according to gender. The gender distribution indicated 108 (52.2%) male and 99 (47.8%) female children in Aseki-Menyamya district; 76 (57.6%) male and 56 (42.4%) female children in Gouno Lufa district. The summary statistics of the UIC for the male and female children are presented in Table 5.

The median UIC for the male and female children in Aseki-Menyamya district were 145.8ug/L and 168.0µg/L respectively. The IQR for the male children was 65.8 – 261.0µg/L and for the female children 81.5 – 350.0µg/L. No statistically significant difference ($p > 0.05$) was indicated when the UIC for the male and female children was compared. The UIC was below 100µg/L among 33.3% of the male and 32.3% of the female children. Among the male children the UIC was below 50.0µg/L in 19.4%, compared to 16.2% of the female children.

Table 3: Summary statistics of UI concentrations (µg/L) for the children in the various age groups

	Districts	**Age groups**						
Parameters		**6yrs**	**7yrs**	**8yrs**	**9yrs**	**10yrs**	**11yrs**	**12yrs**
N	Menyamya	31	49	42	20	25	16	24
	Lufa	19	23	10	22	20	14	24
Median (µg/L)	Menyamya	160.0	146.0	135.0	90.0	170.5	189.5	232.6
	Lufa	32.0	43.5	34.5	52.0	54.5	44.0	55.8
IQR (µg/L)	Menyamya	68.0 – 295.0	50.3 – 311.3	67.0 – 263.1	44.4 – 246.8	95.5 – 256.3	137.3 – 425.0	102.6 – 436.3
	Lufa	18.5 – 71.0	29.0 – 71.5	21.8 – 64.8	21.9 – 67.9	35.6 – 79.6	21.4 – 85.5	38.8 – 91.3
Percentage of children with UIC below 100µg/L	Menyamya	32.3%	36.7%	31.0%	60.0%	24.0%	18.8%	25.0%
	Lufa	94.7%	82.6%	90.0%	90.9%	95.0%	85.7%	79.2%
Percentage of children with UIC below 50µg/L	Menyamya	16.1%	24.5%	16.7%	25.0%	8.0%	18.8%	12.5%
	Lufa	52.6%	60.9%	60.0%	40.9%	40.0%	57.1%	41.7%

Table 4: Distribution (%) of children in the various age groups according to the range of UI concentration (µg/L) and status of iodine nutrition

			Percentage of children in various Age groups						
Range of UIC (µg/L)	Status of Iodine Nutrition	**Districts**	**6yrs**	**7yrs**	**8yrs**	**9yrs**	**10yrs**	**11yrs**	**12yrs**
< 20	Severe	Menyamya	9.7	10.2	2.4	10.0	8.0	12.5	8.3
		Lufa	26.3	17.4	20.0	18.2	10.0	21.4	12.5
20 – 49	Moderate	Menyamya	6.5	14.3	14.3	15.0	0	6.3	4.2
		Lufa	26.3	43.5	40.0	22.7	30.0	35.7	29.2
50 – 99	Mild	Menyamya	16.1	12.2	14.3	35.0	16.0	0	12.5
		Lufa	42.1	21.7	30.0	50.0	55.0	28.6	37.5
100 – 199	Optimal	Menyamya	29.0	22.4	40.4	15.0	40.0	37.5	16.7
		Lufa	5.3	17.4	10.0	4.5	5.0	24.3	20.8
200 – 299	Risk of IIH	Menyamya	16.1	14.3	11.9	5.0	12.0	6.3	16.7
		Lufa	0	0	0	4.5	0	0	0
≥300	Risk of adverse health	Menyamya	22.6	26.5	16.7	20.0	24.0	37.5	41.7
		Lufa	0	0	0	0	0	0	0

Fig. 1: Median UIC (µg/L) of children in the various age groups in Aseki-Menyamya and Gouno Lufa districts

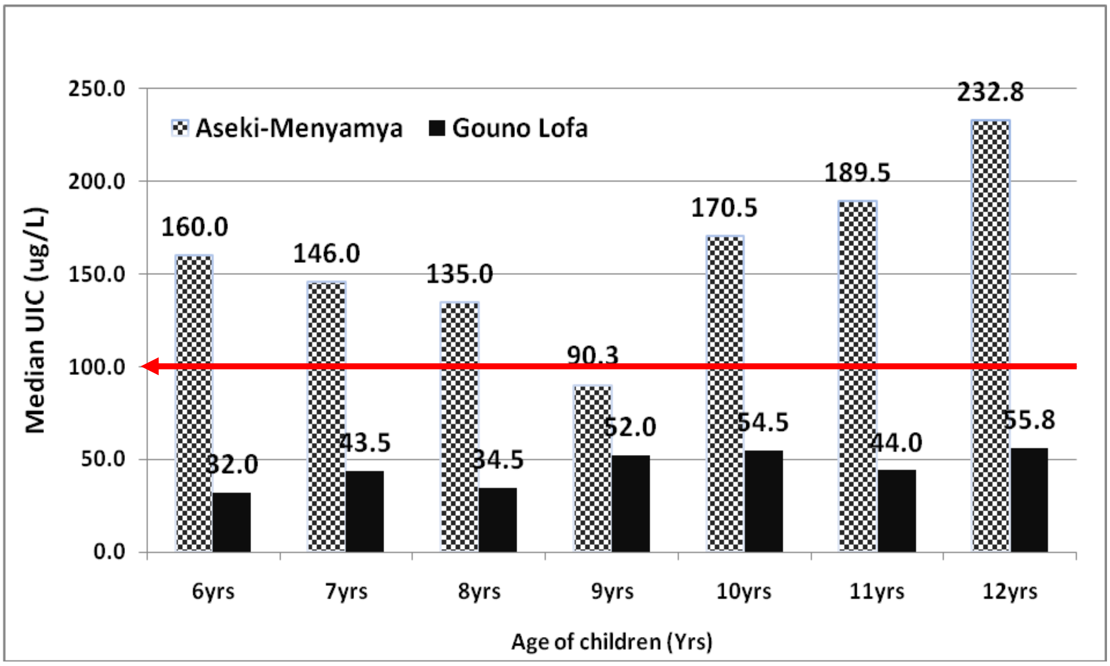

Table 5: Summary statistics of the UIC (ug/L) of the male and female children

Parameters	**Aseki-Menyamya**		**Gouno Lufa**	
	Male	**Female**	**Male**	**Female**
N	108	99	76	56
Median (µg/L)	145.8	168.0	51.3	46.3
Interquartile Range (µg/L)	65.8 – 261.0	81.5 – 350.0	21.6 – 82.1	29.1 – 69.5
Mean (µg/L)	187.4	229.7	59.0	54.9
Std dev	156.0	196.3	41.3	38.6
95% Confidence Interval (p=0.05)	157.7 – 217.2	190.5 – 268.8	49.6 – 68.5	44.6 – 65.3
% (n) of children with UIC below 100µg/L	33.3% (36)	32.3% (32)	85.5% (65)	91.1% (51)
% (n) of children with UIC below 50µg/L	19.4% (21)	16.2% (16)	44.7% (34)	55.4% (31)

Table 6: Percent distribution (n) of the male and female children according to the range of UIC (µg/L) and status of iodine nutrition

Range of UIC (µg/L)	**Status of Iodine Nutrition**	**Aseki-Menyamya**		**Gouno Lufa**	
		Male (n = 108)	**Female (n = 99)**	**Male (n = 76)**	**Female (n = 56)**
<20	Severe	7.4% (8)	9.1% (9)	21.1% (16)	12.2% (7)
20 – 49	Moderate	12.0% (13)	7.1% (7)	23.7% (18)	42.9% (24)
50 – 99	Mild	13.9% (15)	16.2% (16)	40.8% (31)	35.7% (20)
100 – 199	Optimal	30.6% (33)	27.3% (27)	14.5% (11)	7.1% (4)
200 – 299	Risk of IIH	14.8% (16)	10.1% (10)	0	1.8% (1)
≥300	Risk of adverse health	21.3% (23)	30.3% (30)	0	0

For Gouno Lufa district, the median UIC for the male and female children were 51.3µg/L and 46.3µg/L respectively. The IQR for the male children was 21.6 – 82.1µg/L, and for the female children 29.1 – 69.5µg/L. There was no statistically significant difference ($p > 0.05$) between the UIC of the male and female children. A total of 85.5% male and 91.1% female children had UIC below 100µg/L. The UIC was below 50µg/L in 44.7% of the male and 55.4% of the female children.

Statistically significant difference ($p < 0.01$) was obtained when the UIC for the male children in Aseki-Menyamya was compared with that of the male children in Gouno Lufa. Similar result was obtained between the female children.

Distribution of the male and female children according to the range of UIC and status of iodine nutrition is presented in Table 6. For Aseki-Menyamya, 7.4% of the male children were in severe status of iodine nutrition compared to 9.1% of the female children. Moderate status of iodine nutrition was prevalent among 12.0% of the male and 7.1% of the female children. Mild status was prevalent among 13.9% and 16.2% of the male and female children respectively.

For children in Gouno Lufa, although severe status of iodine nutrition was higher (21.1%) among the male children compared to the female children (12.5%), moderate status was higher among the female children (42.9%) compared to the male children (23.7%). The prevalence of severe to mild status of iodine nutrition was, however higher among the female children (91.1%) compared to the male children (85.5%); this difference was not statistically significant ($p > 0.05$).

DISCUSSION:

According to WHO/UNICEF/ICCIDD and other expert committees (1 – 5, 9 – 11) schoolchildren in the 6 – 12 years age group are the useful targets for assessment of the status of iodine nutrition in a population because of their high vulnerability to iodine deficiency and easy accessibility in the community. The school-based approach was used in this study also because of the high enrolment and attendance of both male and female children in primary schools in Morobe province and EHP [19].

The iodine content was greater than 15ppm in the nine brands and the four brands of salt from Aseki-Menyamya and Gouno Lufa districts respectively; this indicates partial implementation of the USI strategy in both districts. However, both districts defaulted in the implementation of the PNGFSR, because 22.2% and 50% of the brands of salt in Aseki-Menyamya and Gouno Lufa districts respectively were below 30ppm. This indicates the need for effective monitoring of the implementation of the PNGFSR in both districts. The low iodine content in the traditional salts (the ash obtained by burning shrubs and canes), strongly suggests the need to discourage their use as the household salt in Aseki-Menyamya district.

The 4.7 ± 2.1g mean per capita per day discretionary consumption of salt obtained in the present study for Gouno Lufa district was within the 3 to 20g range per capita salt intake per day reported for other countries [1, 21, 22]. The result was lower than the 10.0g per capita per day salt intake used in formulating the PNG standards for iodine content in salt indicated in the PNGFSR [8, 12, 15]. It was also lower than the 6.2 to 7.8g reported for Lae City [12] and some areas in Central Province in PNG [14], but higher than the 2.6g reported for Hella region in SHP PNG [13, 14]. The availability of salt in all the selected households strongly supports the use of salt as the major vehicle for iodine supplementation in Gouno Lufa district EHP, PNG.

The mean iodine content of 43.7 ± 24.8ppm for the four brands of salt from the trade-stores was significantly higher ($p < 0.05$) than the mean iodine content (17.8 ± 4.5ppm) in the salt samples from households in Gouno Lufa district. This significant difference may be due to the effects of humidity and poor storage of salt in the households, because 74% of the respondents in Gouno Lufa kept their salt in open plastic containers. Similar findings have been reported by Jooste et al [23] and Sankar et al [24]. Our result indicates that, according to the WHO/UNICEF/ICCIDD criteria [1], the salt samples in 23.8% of the households in Gouno Lufa district were not adequately iodized. Using the criteria in the PNGFSR, the salt samples in 97.6% of households in Gouno Lufa district were not adequately iodized. These findings may indicate inadequate knowledge about the storage and use of iodized salt which is already available in the community. Thus, it is important that program planners carry out intensive nutrition education, information and awareness campaign to advocate for appropriate storage and use of iodized salt in Gouno Lufa district, EHP PNG.

The effective implementation of the USI strategy requires systematic monitoring of UIC, which is the key biochemical indicator recommended for assessing the impact of iodine deficiency control programs [1, 3]. The non-response rates of 6.3% and 2.2% obtained for Aseki-Menyamya and Gouno Lufa districts respectively were lower than the 10% non-response rates used in the calculation of the sample sizes. In both studies the number of male children was slightly higher than that of female children; no specific reasons can be given for these differences. The decision to participate in the study was voluntary and required the approval of the parents or guardians of the school children. Unlike in Gouno Lufa, in Aseki-Menyamya the younger children (age range 6 – 8yrs) were more willing to participate in the study compared to the older (9 – 12yrs) children.

Optimal status of iodine nutrition in a population is achieved when the median UIC is in the 100 – 200µg/L range among children in the 6 – 12 years age group [1 – 5, 7, 9]. The median UIC for the children in Aseki-Menyamya was 149.5µg/L compared to 50.0µg/L for the children in Gouno Lufa. This indicates optimal status of iodine nutrition among the children in Aseki-Menyamya and suboptimal status of iodine nutrition among the children in Gouno Lufa. This difference was further confirmed by the less that 20% of children in Aseki-Menyamya (17.9%) with UIC below 50.0ug/L compared to 49.2% of children in Gouno Lufa. Thus, according to the current WHO/ICCIDD/UNICEF criteria [1 – 5, 7, 9] iodine deficiency was not at the level of public health significance among children in Aseki-Menyamya district. However, severe status of iodine nutrition was prevalent in 8.2% of the children and mild to moderate status of iodine nutrition was prevalent among 24.7% of the children. This should be of concern to program planners in Aseki-Menyamya district and the PNG National Department of Health.

The UIC result for Gouno Lufa indicated that iodine deficiency was potential public health problem among the children; with 17.4% in sever status and 70.4% with mild to moderate status of iodine nutrition. The situation in Gouno Lufa district should be of great concern to the authorities and the program planners at all levels of implementation, in the district, province, region and the National Department of Health in PNG.

In Aseki-Menyamya the median UIC for all the children (149.5µg/L) and for the male (145.8µg/L) and female (168.0µg/L) children were higher than the median UIC values obtained for children in Hella Region SHP PNG (48.0µg/L) [13], but lower that the values obtained in Honduras (287.0µg/L), Nicaragua (259.0µg/L), El Salvador (251.0µg/L), Chile (565.0µg/L), Ecuador (590.0µg/L), Brazil (1013.0µg/L) and Mexico (1150.0µg/L) [25].

The median UIC for all the children in Gouno Lufa (50.0µg/L) was higher than the median UIC (48.0µg/L) reported for schoolchildren in Hella Region SHP PNG [13]. The median UIC for the male children (51.3µg/L) in Gouno Lufa was lower than the value reported for male children (67.0µg/L) in Hella SHP PNG; however the value for the female children in Gouno Lufa (46.3µg/L) was similar to the value (44.0µg/L) for the female children in Hella SHP PNG [13]. The high prevalence of severe to mild status of iodine nutrition among the children in Gouno Lufa district may be due to suboptimal discretionary intake of iodine. This is because the mean per capita intake of 4.7g of salt with mean iodine content of 17.8ppm is equivalent to a calculated mean discretionary intake of 83.7µg iodine per day. Assuming that 20% of the iodine in salt is lost during storage and food preparation [1], the calculated discretionary intake of iodine per capita becomes 66.9µg per day. This amount of iodine is lower than the 90 to 120µg daily intake of iodine recommended for children [1]. This low intake of iodine should be of concern to program planners in the Gouno Lufa district and the EHP, because of the severe consequence of iodine deficiency on the children, which may be having deleterious effect upon intelligence, and also on the vulnerable groups in the community, especially pregnant and lactating mothers [1, 4, 5, 7, 9 – 11, 21, 22].

Our results indicated that none of the children in Gouno Lufa district had UIC above 300µg/L compared to those in Aseki-Menyamya with UIC greater than 300.0µg/L in 25.6% of all the children, 21.3% of the male and 30.3% of the female children. This indicates excessive intake of iodine and risk of adverse health among some of the children in Aseki-Menyamya. Excessive intake of iodine has been reported in many countries, particularly when salt iodization is excessive and poorly monitored [1 – 5, 19]. Intake of iodine in excess of 1000µg per day, with similar amount excreted in the urine can be tolerated by some individuals with little or no apparent problems; however regular consumption of large amount of excess iodine can be potentially harmful to susceptible individuals [1, 19]. According to some experts [1 – 5], in some community the problems caused by excessive intake of iodine may be minor compared to those that can be caused by inadequate intake leading to iodine deficiency. Thus, the general concept, "it is better to consume more iodine per day than to consume less", particularly among the vulnerable groups (children, pregnant or lactating women) in the community [1]. It is important therefore for program planners to improve and strengthen the monitoring of USI and the PNGFSR in both districts, to ensure their efficiency, sustainability and functionality.

CONCLUSION:

The availability of salt in all the selected households in Gouno Lufa district strongly supports the use of salt as the vehicle for iodine supplementation in EHP. However, the discretionary intake of iodine in the households was lower than the recommended intake for children. Thus, there is need, for aggressive awareness campaign, intensive nutrition education and information emphasizing the significance of proper storage of iodized salt, and for using appropriate amount of adequately iodized salt; greater attention should however, be given to Gouno Lufa district EHP.

Although iodine deficiency was not at the level of public health significance among the schoolchildren in Aseki-Menyamya district, mild to moderate status of iodine nutrition was prevalent among 24.7% of them. Iodine deficiency was a significant public health problem among schoolchildren in Gouno Lufa district, because of the high prevalence of severe (17.4%) and mild to moderate (70.4%) status of iodine nutrition. This should be of concern to program planners, because of the severe consequence of iodine deficiency on the schoolchildren, which may be having deleterious effect upon their intelligence.

Our findings indicate the urgent need for reassessing the implementation of USI strategy and the PNGFSR especially in Gouno Lufa district; and for efficient, sustainable, systematic and functional monitoring systems to strengthen and improve on the implementation of the iodine deficiency control programs in Aseki-Menyamya and Gouno Lufa districts in PNG.

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