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ABSTRACT:

The strategy of fortifying food grade salt with iodine has been globally successful in increasing iodine intake and significantly reducing the prevalence of iodine deficiency. In addition, the consumption of salt through processed foods is increasing in many countries. The major objectives of the current study were to assess the iodine nutritional status among school children, the availability and awareness of iodised salt, the use of salty condiments and flavourings in households in a remote Zia community. This was a school and community based prospective cross-sectional study carried out in February 2020. The study population included 6 to 12 years old school children in five schools in Zia. Simple random sampling was used to select the children. Salt samples were collected from randomly selected households in the community. Discretionary salt intake was also assessed in a sub-set of households. The size of the thyroid gland of the children was assessed by a single specialist endocrinologist using the standardized procedure for palpation and grading, after which a single urine sample was collected from the children after obtaining informed consent from their parents. A pre-tested questionnaire was used to assess the awareness and use of iodized salt in the households. The iodine content in salt samples was measured using the single wavelength semi-automated WYD Iodine Checker Photometer. The urinary iodine concentration (UIC) was measured by isotopic dilution, using ^{129}I as a spike. The $^{127}I/^{129}I$ ratio was measured by Inductively Coupled Plasma Mass Spectrometry (ICPMS) (quadrupole ICP-MS iCap). The volume of urine required per run was 0.3ml. The mean iodine content of the salt samples from the Households was 31.7 ± 5.9mg/kg. The daily per capita discretionary intake of salt was 5.7 ± 2.2g. The calculated per capita discretionary intake of iodine was 126.5 ± 48.8μg per day. The Median UIC among the children was 147.5μg/L, which indicates normal iodine status at the time of this study. A total of 44.5% of all the children had palpable goiter (grade 1). This may indicate long-standing prevalence of mild status of iodine deficiency. Majority of the households (93.9%) used Maggi Kakaruk stock cubes to make their food salty compared to 90.9% that used salt. Instant noodles/2-minute noodles are the best wheat based alternative processed foods that should be fortified with iodine. Salt and Maggi Kakaruk stock cubes are the two optimal food vehicles for fortification with iodine in this remote community.

Keywords: Iodine deficiency, school children, Zia community, salty condiments

INTRODUCTION:

Iodine deficiency disorders (IDD) refer to the effects of iodine deficiency (ID) on growth and development, particularly brain development that can be prevented by adequate intake of iodine at the appropriate time [1]. This reconceptualization has been one of the major factors in securing much more attention to the problem of ID over the past decade.

ID is the preventable cause of mental retardation in communities with suboptimal intake of iodine [1, 2]. The occurrence of severe ID that leads to endemic cretinism has been significantly reduced in many countries as a result of dietary iodine supplementation programs [1, 2]. However, mild to moderate (sub-clinical) ID still persists in some countries, especially the subtle degrees of mental impairment, which occur in apparently healthy children with suboptimal dietary intake of iodine [1, 2]. The mean IQ of a community with low intake of dietary iodine may be reduced by 10-15 IQ points. The consequences may include decreased educability, apathy and reduced work productivity, leading to impaired social and economic development [1, 2].

The main intervention strategy for prevention and control of ID is universal salt iodization (USI). It is the paramount strategy, as universal underlines the importance that all salt for human consumption, including that which is used in processed foods, and that used for animal consumption be iodized [1 – 4]. The strategy of fortifying food grade salt with iodine has been globally successful in increasing iodine intake and significantly reducing the prevalence of ID. In addition, the consumption of salt through processed foods is increasing in many countries [5, 6]. If the salt contained in such foods is adequately iodized, it can be an important source of iodine [5, 6]. National salt iodization programs should encourage and monitor the use of iodized salt in processed foods.

The USI strategy was implemented in Papua New Guinea (PNG) in June 1995 with enactment of the PNG Salt Legislation, which prohibits the importation and sale of non-iodized salt [7, 8]. According to the findings of the 2005 PNG National Nutrition Survey (PNG NNS 2005), 92.5% of the salt samples from households were adequately iodized [9]. In addition, iodine status was adequate among non-pregnant women of child-bearing age, with median urinary iodine concentration (UIC) of 170µg/L. This indicated that the USI program has been successful in achieving good coverage in urban and accessible rural areas [9].

Mini-surveys [10 – 14] on iodine status carried out after the PNG NNS reported prevalence of mild to moderate status of iodine deficiency among School-age-children (SAC) in Aseki-Menyamya district Morobe province, Lufa district Eastern Highlands province, Karimui-Nomane district and Sina-Sina Yonggomugl districts in Simbu province. Some of these areas are in remote mountainous regions. These studies also reported that the communities have limited access to commercial salt, some of which was not adequately iodized, and there was limited knowledge about the importance of using iodized salt and the consequences of ID on health outcomes. These authors indicated the need for further assessment of the iodine status among the vulnerable communities in the other remote mountainous areas in the country.

The major objectives of the current study were to assess the iodine nutritional status among school children, the availability and awareness of iodised salt, the use of salty condiments and flavourings in households in the Zia community in Huon district Morobe province in PNG. This was done by determination of the discretionary per capita intake of salt per day, the availability of adequately iodised salt, the iodine status of school children (age 6 –12 years) and the use of a questionnaire to assess the use of salty condiments and flavourings in the households.

METHODOLOGY:

Study site and Population: The study was carried out in Morobe Province, which is one of the four provinces in the Momase region in PNG. The province is made up of nine districts: Bulolo, Finschhafen, Huon, Kabwum, Lae, Markham, Menyamya, Nawae and Tawae-Siassi [15].

Zia is located in the Huon district Morobe rural Local Level Government (LLG). The Zia tribal area covers the lower reaches of the Waria Valley and extends along the Solomon Sea north and south of the river mouth. Communities include Zare, Ainse, Siu, Popoe, Dona, Saigara, Pema, Siu, Bau and Eu [15]. They are located about 165 km south-east of Salamaua rural LLG on the social political and ethnic boundary of Oro and Morobe Provinces.

Zia is a remote area. Topography is rough and rugged with poorly developed infrastructure and poor roads, small valleys and flat lands for large cash crops. The Waria River (major one) and its tributaries are fast flowing and swift in washing downstream all that is in their way.
Major mode of transport from Lae city (Capital of Morobe province) to Zia is by motor-boat (dinghy), it takes about seven hours on a dinghy plus about 24 hours working along rugged paths and small valleys.

Staple foods are taro, banana, sweet potato and sago. Some of these food items cannot be grown in the area because of the extensive soil erosion and climate change.

The population is 10,000 to 15,000. Administrative Centre is Morobe for the Zia and four other neighbouring communities: Yekora and Suena to the north of Zia territory, Binadere to the south-east and Mawae to South-west. Of the four, Zia is the largest and dominant tribal group in the Zia area. The Zia speak the language of the same name - Zia, but Tok-Pisin, limited English and some Kote - a church lingua franca is spoken among older people. Among the Zia, the education is generally poor, literacy is very low, worst among girls and women. Health indicators are generally poor, all village aid posts were closed at the time of this project, and this was due to lack of medicine except for the Zaka sub-health centre. The people rely very heavily on traditional herbs and traditional medicine [15].

Sample size: A sample size of 390 school children was targeted for this study based on the Guidance proposed by UNICEF for the Monitoring of Salt Iodization Programmes and Determination of Population Iodine Status [3]. Recognizing that typical samples size calculations cannot be undertaken for median UICs the UNICEF Guidance notes "*Research indicates that around 400 urine samples per population group are required to measure the median UIC with 5% precision and 100 urine samples to measure the median UIC with 10% precision*." Thus, a sample size of 390 with a response rate of 90% was considered adequate to provide sufficient precision in this small-scale study with limited resources.

Study design and sampling: This was a school and community based prospective cross-sectional study carried out in February 2020 among the Zia community in Huon district Morobe rural LLG. During the pre-visit to the site a list of all the schools and houses was prepared. The schools and houses were randomly selected and the age of children recorded. Five schools participated in this study. Simple random sampling was used to select the consented participants for the study. Informed consent was obtained from the appropriate authorities in the communities, schools and households.

A pre-tested questionnaire was used to assess the awareness and use of iodized salt in the households. The questionnaire was given out to the parents/guardians/elders of households to fill at the time of urine collection.

Collection of samples: The major objectives of the study were explained to the community leaders, the head of each school and to the teachers, with a request for them to communicate the information to the parents and guardians of the children.

To assess the availability of salt, households were randomly selected. A teaspoon of salt was collected from the salt available in each household and placed in a labelled zip-locked bag.

To determine the discretionary intake of salt, sealed packets containing 250 g of iodised table salt were distributed to randomly selected households. The number of individuals living in each household and eating food from the same cooking pot/hearth was counted and recorded. The head of the household was requested to use the salt as usual for cooking and eating. Each household was visited three days later to determine the amount of salt remaining in the packet. The number of individuals living in each household was again counted and recorded. The data obtained was used to estimate the average discretionary intake of salt per capita per day.

For the determination of Urinary Iodine Concentration (UIC), single urine samples were collected at the school from each of the selected school children, after obtaining informed consent from their parents or caregivers. Each urine sample was kept in a properly labelled sterile plastic tube with a tight-fitting stopper that was further sealed with special plastic band.

Assessment of thyroid gland by palpation:

The size of the thyroid gland was assessed by a single specialist endocrinologist using the standardized procedure for palpation and grading of the thyroid size [1]. The non-palpable goitre was grade 0; palpable but not visible goitre was grade 1; palpable and visible goitre was grade 2.

The size of the thyroid gland changes inversely in response to alteration in iodine intake, with a lag interval that can vary from a few months to several years [1]. The prevalence of goitre is an index of the degree of longstanding iodine deficiency and therefore is less sensitive than median UIC for the evaluation of a recent change in the status of iodine nutrition in a population [1].

Palpation was used in the present study because ultrasonography is cumbersome and very expensive to carry out in remote areas, especially in resource limited countries. Palpation is the simple acceptable alternative when carried out by a specialist endocrinologist.

Questionnaire on availability and awareness of iodised salt, use of salty condiments and flavourings:
The modified questionnaire used in an earlier study [14, 16] was pre-tested among 25 randomly selected households in Port Moresby. Feedback and suggested changes were provided orally and in writing. This feedback was used to adapt and improve the questionnaire. It was then used in the present study.

The salt samples, urine samples and questionnaires were transported by airfreight to the Micronutrient Research Laboratory (MRL) in the School of Medicine and Health Sciences (SMHS) University of Papua New Guinea (UPNG) for analysis.

Exclusion criteria: All children below 6yrs of age and above 12yrs of age were excluded from the study. Urine samples were collected only from children whose parents or guardians gave consent.

Assay of salt and urine samples: The quantitative assay of iodine content in salt from the households and trade stores was carried out using the WYD Iodine Checker [17]. Each of the salt samples was assayed three times. The Westgard Rules using Levy-Jennings Charts were used for internal bench quality control (QC) for daily routine monitoring of performance characteristics of the WYD Iodine Checker. The Percent coefficient of variation (CV) ranges from 2.5% to 5.0% throughout the analysis.

For quantitative assay of urinary iodine concentration (UIC), aliquots of the urine samples were sent via courier service to the Human Nutrition Laboratory, Institute of Food Nutrition and Health, ETH Zurich, Zurich, Switzerland. The UIC was measured by isotopic dilution, using ^{129}I as a spike. The $^{127}I/^{129}I$ ratio was measured by Inductively Coupled Plasma Mass Spectrometry (ICPMS) (quadrupole ICP-MS iCap). The volume of urine required per run was 0.3ml [18].

Data analysis and interpretation: The Statistical Package for Social Sciences (SPSS) software (version 21 for Windows) and the Microsoft 365 Excel Data Pack were used for statistical analyses of the data. Shapiro-Wilks test was used to assess normality of the data. Mann Whitney U and Wilcoxon W tests were used for differences between two groups; Kruskal-Wallis and Friedman were used for comparison of all groups. A p-value of < 0.05 was considered as statistically significant.

The criteria used for interpretation of the salt iodine data were based on the PNG salt legislation [7, 8]. According to the legislation all salt must be iodised with potassium iodate; the amount of iodine in table salt should be 40.0 to 70.0 ppm (mg/kg); the amount of iodine in other salt should be 30.0 to 50.0 ppm. These levels of iodine should be present at production or import level. WHO recommendations for iodine levels of food grade salt aim to provide 150 μg iodine per day, assume 92% bioavailability, 30% losses from production to household level before consumption and variability of ±10% during iodisation procedures [4]. If 30% of iodine is lost from salt iodised per PNG food regulations, iodine content of table salt at household level should be at least 28 ppm (40 ppm minus 30%). This implies that in PNG the iodine content in salt in retail outlets or at the time of consumption should be at least 28.0 ppm [7, 8]. A cut-off of 30.0 ppm has been used in the analysis of this study by rounding up this figure. Global norms for iodine levels of salt at household level are 15 ppm based on the assumption that average salt consumption of 10 g per day would provide the adult iodine requirement of 150 µg per day [1]. Salt with iodine levels of less than 5 ppm is considered non-iodised salt [3].

For the UIC data, the recommended WHO/UNICEF/ICCIDD (IGN) criteria were used to characterise the status of iodine nutrition among the school children [1]. According to the criteria, a population of school-age children is considered iodine deficient if the median UIC is below 100.0µg/L. In addition, less than 20% of the urine samples should have UIC below 50.0µg/L. The median UIC can also be used to indicate the severity of iodine deficiency; for example, a population with median UIC below 20.0µg/L is considered severely deficient; moderately or mildly deficient if median UIC is 20.0 to 49.0µg/L or 50.0 to 99.0µg/L respectively [1].

A total of 190 survey questionnaires were randomly distributed among members in the Zia community. The completed questionnaires were collected and transported to the MRL SMHS UPNG for analysis. The questionnaires were coded and the data entered into an Excel database. The data was analysed using SPSS software (version 21 for Windows).

Ethical approval: Ethical approval was obtained from the Ethics and Research Grant committee in SMHS UPNG and the PNG National Department of Health Medical Research Advisory Committee (NDoH MRAC). In additions, verbal consent was obtained from village authorities, and each adult participant and primary caretaker of the children. The consent of each of the participants was documented on the respective interview form. This consent procedure was approved by the ethics committees.

RESULTS:

Availability of salt in households:

To assess the availability of salt in the households, a total of 163 children were each given a zip locked bag and asked to bring a spoon of the salt from their household. A total of 159 zip-lock bags with salt were retuned. This indicates that salt was available in 97.5% (159/163) of the households.

Assessment of Iodine content in salt from Households and trade stores:

The summary statistics of the Iodine content in the salt samples from the households are presented in Table 1. The mean (± STD) Iodine content was 31.7 ± 5.9mg/kg (ppm), range was 8.3 – 43.5 mg/kg. The distribution of the iodine content in salt samples from households based on the criteria in the PNG salt Legislation, shows that iodine content was inadequate (5.0 – 29.9 mg/kg) in 37.1% (59/159) of the salt samples and adequate (30.0 – 50.0 mg/kg) in 62.9% (100/159). Using the criteria recommended by the WHO/IGN/IGN [3, 4], 98.7% (157/159) of the households had salt with iodine content above the 15.0mg/kg for adequately iodized salt. This is above the 90.0% recommended coverage for households with adequately iodized salt that should indicate effective implementation of the USI strategy [3, 4]. The mean iodine content in the three brands of salt from the trade stores were 35.5mg/kg, 37.5mg/kg and 25.7mg/kg respectively.

Table 1: Summary statistics of the Iodine content in mg/kg (ppm) in salt from households in Zia community

Parameters	Iodine content (mg/kg)
Mean	31.7 mg/kg
Standard Deviation (STD)	5.9
95% Confidence Interval (95% CI)	30.8 – 32.6 mg/kg
Range	8.3 – 43.5 mg/kg
Median	32.3 mg/kg
Interquartile range (IQR)	27.4 – 36.2 mg/kg

Assessment of discretionary intake of salt in households:

The assessment of discretionary intake of salt was conducted by providing a pre-weighed (250g) package of iodised salt to the heads of 40 randomly selected households to use for food preparation and consumption as usual. During the first visit, consent was obtained from the head of the household and the total number of individuals in the household was recorded. Each household was revisited three days later. The salt remaining in the package was reweighed to the nearest 0.1g and the total number of individuals in the household was rechecked. The total amount of salt consumed was calculated and used to determine the per capita discretionary intake of salt per day. The frequency distribution of the discretionary intake (g) of salt per capita per day in the various households shows that among the 40 households 25.0% (10/40) were consuming between 2.0 to 5.0 g of salt per capita per day and 75.0% (30/40) were consuming between 6.0 to 10.0 g of salt per capita per day. The summary statistics of the discretionary intake of salt per capita per day is presented in Table 2. The mean per capita discretionary intake of salt was 5.7 ± 2.2 g/day and the range was 1.7 to 10.0 g/day.

Table 2: Summary statistics of the per capita discretionary intake (g) of salt per day in households in Zia community

No (number of households)	40
Mean	5.7 g/day
Standard deviation (STD)	2.2
95% Confidence Interval (95% CI)	5.0 – 6.5 g/day
Range	1.7 – 10.0 g/day
Median	5.4 g/day
Interquartile range (IQR)	4.3 – 7.7 g/day

Mean per capita discretionary intake of iodine per day in households in Zia:

In the households the mean discretionary intake of salt per capita per day was 5.7 ± 2.2g and the mean iodine content in the salt was 31.7mg/kg. Thus, the calculated mean discretionary intake of iodine per capita per day was 180.7 ± 69.7μg, with a range of 53.9 to 317.0μg per capita per day.

Assuming that 30% of the iodine in salt was lost during storage and food preparation, the calculated per capita discretionary intake of iodine becomes 126.5 ± 48.8μg per day, with a range of 37.7 to 221.9μg per day. Thus, the calculated mean discretionary daily per capita intake of iodine is within the 90.0μg to 120.0μg recommended daily requirement of iodine for children, but below the 150 to 200μg recommended for non-pregnant, pregnant and lactating women in the households [1, 3, 4].

Anthropometry**:**

A total of 388 children age 6 to 12 years selected from 5 schools in the Zia community Huon district participated in this study. The anthropometric parameters of all the children are presented in Table 3. Their mean weight was 25.1 ± 6.5 kg and the range was 13.2 to 56.9 kg. Their mean height was 126.9 ± 11.6 cm and the range was 90.5 to 160.0 cm.

Table 3: Anthropometric parameters of all the children and of the male and female children

	All children (n = 388)		Males (n = 227)		Females (n = 161)	
	Weight (kg)	Height (cm)	Weight (kg)	Height (cm)	Weight (kg)	Height (cm)
Mean	25.1	126.9	24.8	126.3	24.5	127.7
Std Dev	6.5	11.6	5.8	11.2	7.4	12.2
95% CI	24.4 – 25.7	125.7 – 128.0	24.0 – 25.6	124.8 – 127.7	24.3 – 26.6	125.8 – 129.6
Range	13.2 – 56.9	90.5 – 160.0	13.2 – 46.7	90.5 – 156.0	13.3 – 56.9	102.0 – 160.0
Median	24.3	126.5	24.3	126.0	24.2	127.5

The 388 children were separated according to their gender; 58.5% (227/388) of the children were male and 41.5% (161/388) were female. The mean weight of the male children was 24.8 ± 5.8kg and the mean height was 126.3 ± 11.2cm. For the female children the mean weight was 24.5 ± 7.4kg and the mean height was 127.7 ± 12.2 cm (Table 3). There was no statistically significant difference between the weight of the male and female children, and also between the height of the male and female children.

Urinary Iodine Concentration (UIC):

To assess the Iodine status of the school children in the community, a total of 388 children were randomly selected from 5 primary schools. Casual urine samples were collected from 381 children after obtaining informed consent from their parents. This gave a consent rate of 98.2% (381/388).

The Kolmogorov-Smirnov test (p = 0.001) for normality confirms that the UIC (μg/L) for the children was not normally distributed. Thus, non-parametric statistics were used for analysis of the UIC data. The summary statistics of the UIC (μg/L) are presented in Table 4. The Median UIC for all the children was 147.5μg/L and the Interquartile Range (IQR) was 110.4 – 215.0μg/L. In addition, 3.7% had UIC below 50.0μg/L. The results indicate normal status of iodine nutrition at the time of this study.

Table 4: Summary statistics of Urinary Iodine Concentration (μg/L) for all the children and for the male and female children

	All children (n =381)	Male children (n = 221)	Female children (n = 160)
Median UIC (μg/L)	147.5	153.4	141.2

Interquartile Range (IQR) (µg/L)	110.4 – 215.0	111.7 – 217.7	103.3 – 206.8
95% Confidence interval (Bootstrapping) (µg/L)	138.2 – 157.2	143.1 – 166.7	129.4 – 154.4
Percent (n) of children with UIC below 50µg/L	3.7 (14)	3.6 (8)	3.8 (6)

The UIC data for the children were separated according to gender; 58.0% (221/381) were male and 42.0% (160/381) were female children. The summary statistics of the UIC (µg/L) for the male and female children are presented in Table 4. Using the Mann-Whitney U and Wilcoxon W tests, no statistically significant difference ($p = 0.751$, 2-tailed) was observed between the UIC for the male and female children.

Goiter rate**:**

Goiter was palpable (grade 1) on 44.5% (169/380) of the children, but not palpable (grade 0) on 55.5% (211/380). Urine samples were collected from 380 (97.9%) of the 388 children. The summary statistics of the UIC for children with palpable and non-palpable goiter are presented in Table 5.

The median UIC for the children with palpable goiter was 156.40µg/L and the IQR was 109 – 229µg/L. For the children with non-palpable goiter the median UIC was 145.6µg/L and the IQR was 111 – 209µg/L. There was no statistically significant difference in the UIC for children with palpable goiter compared to those with non-palpable goiter ($p = 0.67$, 2-tailed).

The results for goiter were further analyzed according to gender. Table 5 shows the number of male and female children with palpable and non-palpable goiter. The summary statistics of the UIC for the male and female children are also presented in Table 5. There were no statistically significant differences between the male and female children with and without palpable goiter.

Table 5: Summary statistics of UIC of all the children and for the male and female children with palpable and non-palpable goiter

	All children (n = 380)		Male children (n = 220)		Female children (n = 160)	
	Palpable goiter	Goiter not palpable	Palpable goiter	Goiter not palpable	Palpable goiter	Goiter not palpable
Percent (n)	44.5% (169)	55.5%(211)	38.6% (85)	61.4% (135)	52.5% (84)	47.5% (76)
Median (µg/L)	156.4	145.6	163.4	149.4	143.5	139.9

IQR (μg/L)	109 – 229	111 – 209	117 – 235	111 – 216	103 – 217	109 – 188
Bootstrapping (95% CI) μg/L	163 – 194	151 – 172	160 – 205	151 – 182	148 – 190	139 – 172
% (n) with UIC below 50μg/L	4.7% (8)	2.8% (6)	5.9% (5)	2.2% (3)	3.6% (3)	3.9% (3)

Assessing the availability and awareness of Iodised Salt, use of Salty Condiments, Flavourings, and Fortification Food Vehicles in the Zia community:

Of the 190 questionnaires distributed, 180 were collected. A total of 172 questionnaires were found suitable for analysis. This gave a response rate of 90.5% (172/190). Both English and Tok-Pisin versions of the questionnaire were presented to each of the respondents with a request to select the one that was appropriate for them to complete. Assistance was provided to those who requested help in completing the questionnaires.

Socio-demographic characteristics of the respondents:

The socio-demographic characteristics of the respondents are presented in Table 6. The mean age of all the respondents was 31.8 ± 14.5 years, age range 15.0 to 93.0 years. Gender distribution of the respondents shows that 41.3% (71/172) were females and 58.7% (101/172) were males. For further presentation of the results, the data was not be separated according to gender.

Of the 172 respondents 53 (30.8%) had no formal education, 94 (54.6%) had primary education, 24 (14.0%) had secondary education and only 1 (0.6%) completed university. At the time of this study, the university graduate was on holidays in the village. It is important to note that low education level and remoteness may contribute to apparent lack of awareness of the importance of iodised salt in a community. For their marital status, 60.3% (102/169) of the respondents were married.

The respondents were asked if they had a salaried job. Of the 168 that answered this question, 87.5% (147/168) said that they do not have a job with salary. This is because most of them are either fishermen or subsistence farmers. They do not consider the amount of money that they receive after selling their products as salary.

TABLE 6: Socio-Demographic Characteristics of Respondents		
1.	Gender (N = 172)	
	Females	41.3% (71/172)
	Males	58.7% (101/172)

2.	Age (years) of participants	
	Mean age of females (years) (N =71)	29.3 ± 14.5
	Mean age of males (years) (N = 101)	33.6 ± 14.5
	Mean age of respondents (years) (N = 172)	31.8 ± 14.5
	Age range of respondents (years)	15.0 – 93.0
3.	Education level (N = 172)	
	Primary	54.6% (94)
	Secondary	14.0% (24)
	University	0.6% (1)
	None	30.8% (53)
4.	Marital status (N = 169)	
	Single	34.9% (59)
	Married	60.3% (102)
	Separated / Divorced	1.8% (3)
	Widow / Widower	3.0% (5)
5.	Do you have a job with a salary (pay)? (N = 168)	
	Yes	12.5% (21)
	No	87.5% (147)

Availability and Awareness of Iodized Salt and use of Salty Condiments, Flavourings, and Fortification Food Vehicles:

The questionnaire contains 21 questions. The results obtained are presented in Table 7. In response to the first question (Q1) "*Does your household use anything to give food a salty taste?*" The response by 96.5% (164/170) of the respondents was in the affirmative.

The second question (Q2) was to select from a list provided the products used in the household (HH) to give food a salty taste. Salt bought from the markets or shops was selected by 90.9% (149/164) of the respondents; Maggi Kakaruk stock cube was the next product selected by 93.9% (154/164) of respondents, followed by Super Chicken stock cubes by 45.7% (75/164) of the respondents.

When asked (Q3), how often products other than salt bought at the market and shop were used in their HH, respondents stated that Maggi Kakaruk stock cube was used more frequently, compared to the other products; 50.6% (78/154) used Maggi Kakaruk every day, 41.6% (64/154) used it several times a week. The results showing frequency of use of the other products are presented in Table 7.

In order to assess the availability of salt in the HH, the 149 respondents that use salt were asked (Q4) *"Does your family have salt bought at market/shop in the household today?"* A total of 95.3% (142/149) of the respondents answered in the affirmative. The next question (Q5) was for those that answered negative to Q4. Of the 7 respondents 5 (71.4%) answered in the affirmative. Those that answered negative to Q5 were asked Q6. One of the two respondents asked Q6 answered in the affirmative, that the HH has salt "bought in the market/ shop any day in the last 7 days". The result, however, indicates that majority of the respondents had some amount of salt in the HH on any day in the preceding seven days.

In response to the question (Q7), if iodised salt was available in the local market/shop where food is commonly purchased, 93.9% (123/131) said "Yes". Respondents that use salt were asked (Q8) "*What do you do with the salt bought at market/shop?*" Four options were provided; *they were asked to select as many as possible*. In response, 81.2% (121/149) stated that they use salt for cooking and add it to food before eating; 30.9% (46/149) use salt for cooking only; 16.1% (24/149) add salt to food before eating only and 49.7% (74/149) of the respondents stated that they also have other uses for salt. They did not specify as requested in the questionnaire, but verbally stated that they use salt for preparation of herbal remedies and preparation of chicken feeds.

The respondents were asked (Q9) "*Why do you buy salt at market/shop only once a month or less?"* 2.7% (4/149) said that salt was too expensive, 32.9% (49/149) said salt was not always available, 40.9% (61/149) said that they do not like salt and 23.5% (35/149) prefer to use other products to make food salty. The respondents were then asked (Q10) "*If iodised salt was easily available at market/ shop and was affordable, would your household buy it?*" The answer was "Yes" by 90.9% (149/164) of the respondents.

In order to assess the awareness and knowledge about the importance of iodised salt, the respondents were asked (Q11) *"Do you think there are health benefits using iodised salt bought from market/shop?* Of the 152 respondents that answered the question, 40.1% (61) said "Yes" and 52.6% (80) said that they were not sure.

To obtain information about commonly available commercial foods that can be fortified the respondents were asked (Q12) "*Does your household have wheat flour or wheat flour foods such as dried noodles, pasta, macaroni, instant noodles; 2-minute noodles, bread, buns, rolls, cake, crackers, biscuits, scones, donuts today?*" Only 32.3% (53/164) of respondents said "Yes". The next question (Q13) to the 111 respondents that answered in the negative was "*If No, did your household have wheat flour or wheat flour foods, such as, dried noodles, pasta, macaroni, instant noodles, 2-minute noodles, bread, buns, rolls, cake, crackers, biscuits, scones, donuts yesterday?*" a total of 38.7% (43/111) said "Yes", compared to 61.3% (68/111) that said "No". The follow up question (Q14) was to the 68 respondents that answered in the "negative". Of the 68 respondents, 44 (64.7%) said "Yes". This indicates that these products were available in the HH of a relatively large number of the respondents in the last seven days.

In the next question (Q15) those participants that had responded "Yes" to the questions on wheat (Q12, Q13 and Q14) were asked which wheat products they had in their HH, and that they could choose as many as necessary from the options given. A total of 140 respondents answered Q15. The result is presented in Table 7. In summary, 85.0% (119/140) of the respondents selected "Instant noodles/2-minute noodles" as the most popular wheat product in their HH. Both "Crackers/biscuits" and "Wheat flour" were the next products selected by 22.1% (31/140) of the respondents.

The next set of questions (Q16, Q17, and Q18) was on the availability of rice in the HH. In response to Q16, a total of 52.9% (90/170) of respondents did not have rice in the HH on the day of the visit. In response to Q17, 51.1% (46/90) did not have rice in the HH the previous day, and in response to Q18, 56.5% (26/46) said they did not have rice in the HH any day in the last seven days.

Respondents were also asked (Q19, Q20, and Q21) about the availability of oil in their HH. On the day of the visit, 59.4% (101/170) did not have oil in their HH. In response to the next question Q20, if they had oil in the HH the previous day, 65.3% (66/101) responded in the negative. They were then asked if they had oil in the HH any day in the last seven days; 54.5% (36/66) also responded in the negative.

Table 7: Summary of answers on availability and awareness of iodised salt, and use of salty condiments, flavourings, and fortification food vehicles

Q1	Does your household use anything to give food a salty taste? (N = 170)	% (N)
	1. Yes	96.5% (164)
	2. No	3.5% (6)
	3. Not sure	0
Q2	If yes, what do you use? Select as many as apply (N = 164) (some participants selected more than one product)	
	1. Salt bought at market / shop:	90.9% (149)
	2. Maggi Kakaruk stock cubes	93.9% (154)
	3. Super chicken stock cubes:	45.7% (75)
	4. Soya/ Maggi sauce	32.9% (54)
	5. Kakaruk salt:	19.5% (32)
	6. Other seasoning:	13.4% (22)

	7. Ash/traditional salt:	3.7% (6)
	8. Salty water from river/sea	25.6% (42)
Q3	How often do you use the products (other than salt bought at the market /shop) mentioned in question 2? (Give details for the first 3 products)	
	Maggie Kakaruk stock cubes (n = 154):	
	1. Everyday	50.6% (78)
	2. Several times a week	41.6% (64)
	3. Once a week	4.5% (7)
	4. Once a month or less	3.2% (5)
	Super chicken stock cubes (n = 75):	
	1. Everyday	37.3% (28)
	2. Several times a week	46.7% (35)
	3. Once a week	10.7% (8)
	4. Once a month or less	5.3% (4)
	Soy / Maggie sauce (n = 54):	
	1. Everyday	22.2% (12)
	2. Several times a week	44.4% (24)
	3. Once a week	18.5% (10)
	4. Once a month or less	14.8% (8)
Q4	Does your family have salt bought at market / shop in the household today? (N = 149)	
	1. Yes	95.3% (142)
	2. No	4.7% (7)
Q5	If no, did your household have salt bought at market / shop yesterday? (N = 7)	
	1. Yes	71.4% (5)
	2. No	28.6% (2)
Q6	If no, did your household have salt bought at market / shop any day in the last 7 days? (N = 2)	
	1. Yes	50% (1)
	2. No	50% (1)
Q7	Is iodised salt available in the local market / shop where food is commonly purchased? (N = 131)	
	1. Yes	93.9% (123)
	2. No	3.1% (4)
	9. Not sure	3.0% (4)
Q8	What do you do with the salt bought at market / shop? Select as many as possible (N =149) (More than one option was selected; total does not add up to 100%)	
	1. Use for cooking and add to food before eating	81.2% (121)
	2. Use for cooking only	30.9% (46)
	3. Add to food before eating only	16.1% (24)
	4. Other uses (Specify)	49.7% (74)
Q9	Why do you buy salt at market / shop once a month or less? (N = 149)	
	1. Too expensive	2.7% (4)
	2. Not always available	32.9% (49)
	3. Do not like it	40.9% (61)
	4. Prefer to use other products to make food salty	23.5% (35)

Q10	If iodised salt was easily available at market / shop and was affordable, would your household buy it? (N = 164)	
	1. Yes	90.9% (149)
	2. No	7.3% (12)
	9. Not sure	1.8% (3)
Q11	Do you think there are health benefits using iodised salt? (N = 152)	
	1. Yes	40.1% (61)
	2. No	7.2% (11)
	9. Not sure	52.6% (80)
Q12	Does your household have wheat flour or wheat flour foods such as dried noodles, pasta, macaroni, instant noodles; 2-minute noodles, bread, buns, rolls, cake, crackers, biscuits, scones, donuts today? (N = 164)	
	1. Yes	32.3% (53)
	2. No	67.7% (111)
Q13	If no, did your household have wheat flour or wheat flour foods such dried noodles, pasta, macaroni, instant noodles, 2-minute noodles, bread, buns, rolls, cake, crackers, biscuits, scones, donuts yesterday? (N = 111)	
	1. Yes	38.7% (43)
	2. No	61.3% (68)
Q14	If no, did your household have wheat flour or wheat flour foods such as dried noodles, pasta, macaroni, instant noodles, 2-minute noodles, bread, buns, rolls, cake, crackers, biscuits, scones, donuts on any day in last 7 days? (N = 68)	
	1. Yes	64.7% (44)
	2. No	35.3% (24)
Q15	If you responded “Yes” to question 12, 13, or 14, which food did you have in your household (tick all that you have)? (N = 140) (Some selected more than one thus, the total does not add up to 100%)	
	1. wheat flour	22.1% (31)
	2. dried noodles/macaroni/pasta	16.4% (23)
	3. Instant noodles/2-minute noodles	85.0% (119)
	4. Bread/buns/rolls/	5.7% (8)
	5. Crackers/biscuits	22.1% (31)
	6. Cake/scones/donuts	12.1% (17)
Q16.	Does your household have rice today? (N = 170)	
	1. Yes	47.1% (80)
	2. No	52.9% (90)
Q17.	If no, did your household have rice yesterday? (N = 90)	
	1. Yes	48.9% (44)
	2. No	51.1% (46)
Q18.	If no, did your household have rice any day in the last 7 days? (N = 46)	
	1. Yes	43.5% (20)
	2. No	56.5% (26)
Q19.	Does your household have oil today? (N = 170)	
	1. Yes	40.6% (69)
	2. No	59.4% (101)
Q 20.	If no, did your household have oil yesterday? (N = 101)	
	1. Yes	34.7% (35)

	2. No	65.3% (66)
Q 21.	If no, did your household have oil any day in the last 7 days? (N = 66)	
	1. Yes	45.5% (30)
	2. No	54.5.% (36)

DISCUSSION:

Effective implementation and monitoring of the USI is the most equitable and sustainable strategy to ensure optimal iodine nutrition for all population groups [3]. It is the main strategy for achieving sustained IDD control among all groups in the urban, rural and remote communities worldwide. Thus, the need to ensure adequate iodization of all food grade salt cannot be overemphasized. Quantitative assessment of the iodine content in salt is one of three parameters that can be used for assessing the iodine status in a population [1, 3]. It is the most important "Process" indicator for monitoring progress in the implementation of the USI, which is one of the most effective and sustainable long-term public health measures for the prevention and control of iodine deficiency [1, 2, 3].

In this project, the PNG salt legislation [7, 8] was used to evaluate the iodine content in salt available in the households. The daily per capita discretionary intake of salt was 5.7 $\pm$ 2.2g. This value is lower than the recommended 10.0g per capita per day salt intake stipulated in PNG salt legislation [7, 8]. It is also lower that the 6.59g per capita per day intake in Lae City Morobe province [19] and the 6.0g reported for households in Sina-Sina Yonggomugl in Simbu [14]. However, it is higher than the 2.62g per capita per day salt consumption in Hela region [10], the 4.7g and 4.6g per capita per day reported in Eastern Highlands and Karimui-Nomane in Simbu provinces [11].

Of the 163 households selected in the present study, no salt was available in 4 (2.5%) of the households; in addition, the iodine content in only two (1.3%) of the households with salt was below 15mg/kg. Thus, according to the WHO/UNICEF/IGN criteria [1, 3], 97.5% (159/163) households had adequately iodized salt at the time of this study. This is above the 90.0% recommended coverage of households with adequately iodized salt that should indicate effective implementation of the USI strategy.

However, according to the PNG Salt Legislation, of the 159 households with salt, the iodine content in 59 (37.1%) salt samples was below the 30.0 mg/kg cut-off point recommended in the PNG salt legislation [7, 8]. Salt with iodine content above 30.0ppm was available in 62.9% (100/159) of the households. Thus, 62.9% of randomly selected households in the Zia community had adequately iodized salt at the time of this study. This value is lower than the

90.0% coverage of households with adequately iodized salt that should indicate effective implementation of the PNG Salt legislation. This should be of concern to program planners in the National Department of Health (NDOH) and the Morobe provincial authorities, because of the severe consequences of iodine deficiency in young children, pregnant and lactating mothers, and also because of the devastating effect of iodine deficiency on the developing brains of neonates [1, 2, 3].

Two of the three brands of salt from the trade stores were adequately iodized. The low iodine content in the salt samples from the 37.1% of households might be due to several factors relating to poor storage and handling of the salt in these households. Further study is need to ascertain the factors that could result in loss of iodine in salt in the households.

The calculated mean per capita discretionary intake of iodine was 180.7µg ± 69.7µg/L. This was higher than the 90µg to 120µg daily intake of iodine recommended for children [1]. Assuming that the iodised salt is added directly to the ready-to-eat food, then this is just within the 150µg to 200µg recommended daily requirement of iodine for adults, including pregnant and lactating women [1, 2, 3]. If, however, the iodised salt is added during food preparation, then, factoring in the about 30% loss of iodine in salt during storage and food preparation, the calculated per capita discretionary intake of iodine becomes 126.5µg. This amount is lower than the recommended daily requirement for non-pregnant, pregnant and lactating women [1, 2, 3]. This indicates the need to carry out intensive education and awareness campaigns in the community, advocating the use of iodized salt (when it is available and affordable).

In the present study, the status of iodine nutrition among the children was assessed using the current WHO/UNICEF/IGN recommended epidemiological criteria and the recommended indicators for assessing and monitoring progress towards the elimination of iodine deficiency as a Public Health problem in affected communities [1, 3]. According to the criteria, optimal status of iodine nutrition is achieved when the median UIC in the population is 100 – 200µg/L. The UIC does not usually exceed the dietary intake of iodine; it is therefore possible to use the UIC as a biochemical parameter for assessing the iodine status of a population [1, 3]. The median UIC (µg/L) in a population is the Prime Biochemical Index for evaluating the degree of Iodine Insufficiency in a target population.

School children in the 6 – 12 years age group are recommended for the assessment of iodine nutrition in a population because of their high vulnerability to iodine deficiency and easy accessibility in the community [1]. The school-based approach was used in this study because of the supposedly high enrolments and attendance of both male and female children in primary schools in Huon district.

A total of 388 children were selected randomly from 5 schools. The response rate of 98.2% (381/388) obtained in the present study was higher than the 90.0% predicted response rate used for the determination of the sample size.

The median UIC for all the children was 147.5µg/L and the UIC was below 50.0µg/L among 3.7% (14/381) of the children. This indicates normal status of Iodine nutrition at the time of this study. Thus, Iodine deficiency should not be considered as a significant public health problem among schoolchildren, age 6 – 12 years in the Zia community in Huon districts at the time of this study.

The median UIC value for all the children was higher than the value reported for schoolchildren aged 6 – 12 years in Southern Highlands province, PNG (48.0ug/L) [10], Simbu province (17.5µg/L and 58.5µg/L), Gulf and other remote areas in PNG [14, 16, 20], but lower than the value reported in Keita District Bougainville in PNG (204.5µg/L), Honduras (287ug/L) [21], Nicaragua (259ug/L), El Salvador (251ug/L), Chile (565ug/L), Ecuador (590ug/L), Brazil (1013ug/L) and Mexico (1150ug/L) [22].

Normal status of iodine nutrition was also prevalent among the male and female children with median UIC of 153.4µg/L and 141.2µg/L, respectively. The data shows that, based on the median UIC, the Iodine nutrition status in the Zia community in Huon district should not be considered critical among the male and female children in the 6 to 12 years age group, at the time of this study.

Contrary to the results obtained for the median UIC in the present study, a total of 44.5% of all the children had palpable goiter (grade 1). This indicates long-standing prevalence of mild status of iodine deficiency among the children [1].

Discrepancies between the results for UIC and prevalence of goitre:

Despite the normal status of iodine nutrition based on the median UIC obtained in the present study, 44.5% (169/380) of the children had palpable goitre, which may indicate mild prevalence of iodine deficiency. This discrepancy may be explained by the fact that median UIC reflects the current situation of iodine supply, while thyroid size indicates the long-term iodine status [1, 23].

The prevalence of iodine deficiency determined by the two indicators does not necessarily need to be consistent [23]. The median UIC also indicated adequate intake of iodine at the time of the study.

Another explanation for the discrepancy may be because of the inadvertent error made during the pre-visit to the community to obtain permission before the collection of urine samples. The pre-visit was carried out about five days before commencement of sample collection. Several packets of iodised salt were distributed to the community leaders during the pre-visit. This might have resulted in the high number of households with iodised salt and the high rate of consumption of iodised salt in the households. The donation of the salt packages is one of the traditional ways of obtaining the approval for the project to proceed with full cooperation of the community. Thus, the need for further studies to be carried out to corroborate the results obtained in the present study.

Questionnaire:

More males (58.7%) than females (41.3%) completed the questionnaires. All the respondents were adults with mean age of 31.8 years. The level of education in the community was low, as only 14.6% had attained education above primary school level. Remoteness and low level of education are factors that can contribute to an apparent lack of awareness of the need to consume adequate amounts of iodine for optimal growth and development [1]. This might be one of the reasons for the 44.5% of children with palpable goitre in the present study. According to a recent study, low socioeconomic status and rural residence were found to be risk factors for low household access to salt [24]. In the present study, the donation of adequately iodised salt packages to the community leaders as incentive for participation in the study may have skewed the results.

Majority of the households (93.9%) used Maggi Kakaruk stock cubes to make their food salty, compared to 90.9% that used salt. Among those households that used Maggi Kakaruk cubes, 50.6% use them every day and 41.6% use them several times a week. The results also show that both Maggi Kakaruk cubes and salt are used in most of the households, when they are available and affordable.

The need for advocacy and increased awareness to educate the people about the health benefits of using iodised salt cannot be overemphasized. This is because only 40.1% of the respondents were aware of the health benefits of using iodised salt. Most of them said that they became aware after the presentation made to them during the pre-visit.

On the day of the visit, 85.0% of respondents had Instant noodles/2-minute noodles available in the households compared to 22.1% of households with wheat flour. This strongly suggests that instant noodles/2-minute noodles are the best wheat based alternative processed foods that should be fortified with iodine. This can be achieved by preparing these wheat-based products with adequately iodised salt.

The consumption of rice (47.1%) and oil (40.6%) can be considered as moderate. However, rice was available in 84.7% (144/170) of households at least once in the last seven days. Similarly, oil was available in 78.8% (134/170) of households at least once in the last seven days.

However, salt and Maggi Kakaruk stock cubes are the two optimal food vehicles for fortification with iodine in this remote community.

CONCLUSIONS:

Salt with iodine content above 30.0ppm was available in 62.9% of the households. The low coverage of households with adequately iodized salt at the time of this study indicates poor implementation of the PNG Food Sanitation Regulation. The daily per capita discretionary intake of salt was 5.7g. The calculated per capita discretionary intake of iodine was 126.5µg per day. The median UIC among the children indicates normal iodine status at the time of this study. Contrary to the results obtained for the median UIC, a total of 44.5% of all the children had palpable goiter (grade 1). This may indicate long-standing prevalence of mild status of iodine deficiency. Majority of the households (93.9%) used Maggi Kakaruk stock cubes to make their food salty, compared to 90.9% that used salt. Instant noodles/2-minute noodles are the best wheat based alternative processed food that should be fortified with iodine. Salt and Maggi Kakaruk stock cubes are the two optimal food vehicles for fortification with iodine in this remote community.

Limitations of the study:

One of the major limitations of this study was the way the community elders' cooperation was obtained. Traditionally, the elders' approval for research in some remote communities is secured by providing appropriate incentives to the community leaders for distribution to members of the community. In the present study, several packets of iodised salt were donated to the community leaders in order to obtain their approval for community participation. This may have skewed the results in favor of the high number of households with iodised salt and the high rate of consumption of iodised salt in the households. Thus, more studies should be carried out to corroborate the results obtained in the present study.

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