PACIFIC JOURNAL OF MEDICAL SCIENCES

{Formerly: Medical Sciences Bulletin}

ISSN: 2072 – 1625

Pac. J. Med. Sci. (PJMS)

www.pacjmedsci.com. Emails: pacjmedsci@gmail.com; pacjmedsci1625@gmail.com

STATUS OF IODINE NUTRITION AMONG SCHOOL-AGE CHILDREN IN KARIMUI-NOMANE AND SINA-SINA YONGGOMUGL DISTRICTS IN SIMBU PROVINCE PAPUA NEW GUINEA

***Victor J. Temple[1], Guapo Kiagi[2], Hethy M. Kai[1], Hanifa Namusoke[3], Karen Codling[4], Lazarus Dawa[3] and Eileen Dogimab[5]**

1. Micronutrient Research Laboratory, Division of Basic Medical Sciences, School of Medicine and Health Sciences, University of Papua New Guinea
2. Sir Joseph Nombri Memorial-Kundiawa General Hospital, Simbu Province, Papua New Guinea
3. UNICEF Papua New Guinea; 4. Iodine Global Network; 5 National Department of Health PNG

*Correspondence to: templevj@upng.ac.pg

STATUS OF IODINE NUTRITION AMONG SCHOOL-AGE CHILDREN IN KARIMUI-NOMANE AND SINA-SINA YONGGOMUGL DISTRICTS IN SIMBU PROVINCE PAPUA NEW GUINEA

***Victor J. Temple[1], Guapo Kiagi[2], Hethy M. Kai[1], Hanifa Namusoke[3], Karen Codling[4], Lazarus Dawa[3] and Eileen Dogimab[5]**

1. Micronutrient Research Laboratory, Division of Basic Medical Sciences, School of Medicine and Health Sciences, University of Papua New Guinea
2. Sir Joseph Nombri Memorial-Kundiawa General Hospital, Simbu Province, Papua New Guinea
3. UNICEF Papua New Guinea; 4. Iodine Global Network; 5 National Department of Health PNG

*Correspondence to: templevj@upng.ac.pg

ABSTRACT:
Iodine deficiency is regarded as the single most common cause of preventable mental impairment in communities with suboptimal intake of iodine. Universal Salt Iodization is the most effective and sustainable intervention strategy for prevention, control and elimination of iodine deficiency. Urinary iodine concentration is the biochemical indicator for assessing the iodine status of a population. This study was prompted by reports showing evidence of cretinism in Karimui-Nomane district in Simbu province. The major objectives were therefore to assess the availability of adequately iodized salt in households, the per capita discretionary intake of salt per day and the iodine status of school children (age 6 – 12 years) in Karimui-Nomane, the district of concern, and Sina Sina Yonggomugl, a comparison district in Simbu province. Iodine level was assessed in salt samples collected from randomly selected households in both districts. The head of each household completed a questionnaire on knowledge, attitudes and practices related to salt iodization. Urinary iodine concentrations were measured in spot urine samples collected from randomly selected 6 to 12 years old children from selected primary schools in the two districts. 82.4% and 63.8% of salt samples from Karimui-Nomane and Sina Sina Yonggomugl respectively were adequately iodized above the national standard of 30ppm. The mean per capita discretionary intake of salt in households in Karimui-Nomane district was 4.62 ± 0.42 g/day, and in Sina Sina Yonggomugl district was 6.0 ± 2.61g/day. At measured levels of iodization (mean iodine content 34.7ppm and 32.7ppm respectively), this amount of salt would provide the recommended intake of iodine (150ug/day). However, for children in Karimui-Nomane the median UIC was 17.5µg/L and the interquartile range (IQR) was 15.0 – 43.0µg/L. and in Sina Sina Yonggomugl, the median UIC was 57.5µg/L and the IQR was 26.3 – 103.0µg/L, indicating severe and mild iodine deficiency respectively. These apparently conflicting findings may be explained by the fact that only 34% of households in Karimui-Nomane and 72% of households in Sina Sina Yonggomugl had salt on the day of the survey. The results indicate that iodine deficiency is a significant public health problem in Karimui-Nomane and Sina Sina Yonggomugl districts in Simbu province, potentially because of lack of access to salt, rather than inadequate implementation of salt iodization. Further studies are needed to quantify access to salt for communities in areas that are not easily accessible like Karimui-Nomane district in Papua New Guinea and, if inadequate salt access is confirmed, to develop alternative or complementary strategies to salt iodization.

Keywords: School children, Iodine deficiency, Salt iodization, Urinary Iodine, Simbu province, Papua New Guinea

Submitted November 2017, Accepted December 2017

INTRODUCTION:

Suboptimal intake or low bioavailability of iodine can cause inadequate production of thyroid hormones, which are essential for normal growth and development [1, 2]. Iodine deficiency (ID) can lead to mental retardation in infants and children whose mothers were iodine deficient during pregnancy. ID is also regarded as the single most common cause of preventable mental impairment in communities with suboptimal intake of iodine [1, 2]. Marginal degree of ID can affect "apparently healthy" children – the manifestations may include poor performance in psychometric tests, and impaired mental and motor functions [1, 2]. ID is usually diagnosed across a target population and not specifically in an individual [2].

Universal salt iodization (USI) is the most effective intervention strategy for the control and elimination of ID [1 – 3]. The effective implementation of USI requires continuous monitoring of the process indicator, which is availability of adequately iodized salt in the households and the principal impact indicator, which is the iodine status, most commonly assessed by measuring iodine concentration of single urine samples from a representative sample of individuals in target populations [1, 3]. The sustainability of USI strategy can be assessed by combination of the median urinary iodine concentration (UIC) in the target population, the availability of adequately iodized salt at the households and a set of programmatic indicators that are regarded as evidence of sustainability [1, 2]. Due to wide variation in iodine excretion during the day and in between individuals, UIC cannot be used to assess iodine status of individuals. The median value of UICs in a population can however indicate population iodine status. As a result, median UICs cannot be used to assess the proportion of individuals with iodine deficiency or excess [1, 3].

USI 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 [4, 5]. Reports from the PNG National Nutrition Survey in 2005 indicated that salt was adequately iodized in 92.5% of the households with salt and iodine status among non-pregnant women of child-bearing age was adequate in the four regions of PNG [6]. However, 38% of households had no salt at the time of the survey, and iodine status was lower in women from households without salt [6]. Meanwhile, several sub-national surveys carried out from 1998 to 2016 [7 – 14] indicated prevalence of mild to moderate iodine deficiency in some districts in PNG. However, no published data was available on the salt iodization and status of iodine nutrition in the Simbu province.

The current study was prompted by the report presented by the Chief Pediatrician in Simbu (Chimbu) Province during the midyear consultative meeting of the Pediatric Society of PNG in 2014 [15]. The focus of the report was the nutritional status among infants and children in Karimui-Nomane district in Simbu province. It included cases of cretinism and dwarfism diagnosed based on history taking and clinical examinations; several photographs of the children and family members were displayed. The diagnoses included Failure to Thrive (FTT), very low IQ, severe stunting, delay dentition, abdominal distention, umbilical hernia, unable to stand and walk and clinical evidence of hypothyroidism. The Chief Pediatrician also cited suspected cases of congenital hypothyroidism in the community. Most of the cases were cretins without goiter. Thus, because of lack of appropriate laboratory services, some of the diagnoses were confirmed by X-rays showing suspected characteristics of cretins.

Two of the X-rays showed delay in the development of the carpal bones in the wrist, delay in the development of bone centers of ossification indicative of congenital hypothyroidism, pronounced trabeculae in the structure of the metaphyses in the distal end of the femur and the proximal end of the tibia. The Femoral head center of ossification shows traces (Figs 1a and 1b).

Fig. 1a: X-ray of carpal bones in the wrist [15]

Fig. 1b: X-ray of distal end of femur and proximal end of tibia [15]

These X-rays are similar to those of patients with hypothyroidism [16, 17].

The report further stated that in Karimui-Nomane district there is a salt water stream that flows out from rocks. The salt water was used to flavour foods by the forefathers of the land, the neighbouring tribes and the whole of Simbu province. Local history indicated that it was a great commodity in the past. It was used in exchange for other goods / items and even for bride price payments [15]. A similar report was presented during the midyear consultative meeting in 2015 because of concerns that no action had been taken [15].

The conclusion of both reports was "*an apparently very high prevalence of probably severe iodine deficiency disorders (IDD) exists* *among the population in Karimui-Nomane district, which is one of the remote districts in the Simbu province*". An urgent plea was made for appropriate scientific investigations to be carried out in the district followed by appropriate actions.

The major objectives of this study were therefore to assess the availability of adequately iodized salt in households, the per capita discretionary intake of salt per day and the iodine status of school children (age 6 – 12 years) in Karimui-Nomane and Sina-Sina Yonggomugl districts in Simbu province.

SUBJECTS AND METHODS:

Study sites:

This study was conducted in the Simbu (Chimbu) province located in the highlands region in PNG. The province has an area of 6,112 Km^2 with a population of about 376,473. It shares geographic and political boundaries with five other provinces: Southern Highland, Jiwaka, Eastern Highland, Gulf and Madang. Simbu is a province with very rugged mountainous terrains, including the tallest mountain in PNG, Mt. Wilhelm, and other notable mountains, like Mt. Elimbari, Mt. Digine, and Mt. Crater [18]. The annual rainfall varies between 4,855 mm at high altitudes to 1,599 mm at lower altitudes. There are six districts in Simbu province: Chuave, Gumine, Karimui-Nomane, Kerowagi, Kundiawa-Gimbogi and Sina Sina-Yonggomugl. The provincial capital is Kundiawa, which is located in Kundiawa-Gimbogi district. The specific sites for the study were Karimui-Nomane and Sina Sina Yonggomugl districts. Sina Sina Yonggomugl district was assessed in addition to Karimui-Nomane as a comparison as it is less remote and mountainous and closer to the capital city [18].

Sample size for assay of urinary iodine concentration:

Calculation of sample size used a design effect of three, a relative precision of 10%, and confidence level (CL) of 95% [19]. As there was very limited information on likely prevalence rates of ID in both districts, an assumed prevalence rate of 25% was used for each district. With a predicted non-response rate of 10%, the sample sizes of 300 and 250 school-age children were obtained for Karimui-Nomane and Sina Sina Yonggomugl districts respectively. These sample sizes were considered adequate for a mini-survey with limited resources and also because of the lack of recent data on the status of iodine nutrition among the population in these districts and this province.

Study design and sampling:

This was a prospective school and community based cross-sectional study. The study population included 6 to 12 years old school children randomly selected from the primary schools in the two districts; seven in Karimui-Nomane and three in Sina Sina Yonggomugl. Multistage cluster sampling method was used in both districts. The total enrolments in each of the selected primary schools, including the ages of children in each of the grades were listed. The required number of children from each of the primary schools in each district was selected by simple random sampling.

Salt samples were collected from randomly selected households in Karimui-Nomane and Sina Sina Yonggomugl districts. The head of each household was also requested to complete a questionnaire. The pre-tested questionnaire was used to assess the awareness and use of iodized salt in the households in both districts.

Collection of samples and questionnaires:

The major objectives of the study were explained to the head of each school and to the teachers, requesting them to communicate the information to the parents. Single urine samples were collected at the school from each of the selected school children, after obtaining informed consent from their parents or guardian. Each urine sample was kept in a properly labelled sterile plastic tube with tight fitting stopper that was further sealed with special plastic bands.

To assess the availability of salt, households were randomly selected from a list of households in both districts. For households with salt available at the time of the survey, a teaspoon of salt was collected from the salt available in each household and placed in a labeled zip-locked bag. To determine the discretionary intake of salt, sealed packets containing 250g of iodized table salt were distributed to 50 randomly selected households in each district. The number of individuals living in each household and eating food prepared in the household 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 a second time a few 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 each district.

Two clean properly labelled sterile containers were used to collect water from the salt stream in Karimui-Nomane district.

The completed questionnaires were also collected from the various households. The salt samples, urine samples and questionnaires were appropriately packed into suitable containers and transported by airfreight to the Micronutrient Research Laboratory (MNRL) in the School of Medicine and Health Sciences (SMHS) University of Papua New Guinea (UPNG) for analyses.

Exclusion criteria:

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

Analysis of samples:

The iodine content in the salt samples and the water from the salt stream were determined quantitatively using the WYD Iodine Checker [20]. Internal bench quality control (QC) for daily routine monitoring of performance characteristics of the WYD Iodine Checker was by the Westgard Rules using Levy-Jennings Charts. The percent coefficient of variation (CV) ranges from 2.5% to 5.0% throughout the analysis.

The UIC was determined by Sandell-Kolthoff reaction after digesting the urine with ammonium persulfate in a water–bath at 100°C [1].

Internal bench QC characterization of the assay method was by the Levy-Jennings Charts and the Westgard Rules. In addition, the sensitivity (10.0 – 12.50µg/L) and percentage recovery (95.0 $\pm$ 10.0%) of the urinary iodine (UI) assay were frequently used to assess the performance characteristics of the assay method. External QC monitoring of the 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.

Data analysis and Interpretation:

Microsoft Excel Data Pack 2010 and the Statistical Package for Social Sciences (SPSS) software (version 17) were used for statistical analyses of the data. Shapiro-Wilks 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 PNG salt legislation was the criteria used for interpretation of the iodine content in salt samples. According to the legislation all salt must be iodized with potassium iodate; the amount of iodine in table salt should be 40 – 70ppm (mg/kg); the amount of iodine in other salt should be 30 – 50ppm. This implies that the iodine content in salt at the time of consumption should not be less than 30ppm [4, 5].

The recommended WHO/UNICEF/ICCIDD criteria [1] for the interpretation of UIC data were used to characterize the status of iodine nutrition among the school children in Karimui-Nomane and Sina Sina Yonggomugl districts. According to the criteria, a population of school-age children is considered iodine deficient if the median UIC is below 100µg/L and iodine sufficient if the median is in the range of 100-200µg/L. In addition, not more than 20% of the urine samples should be below 50µg/L in an iodine sufficient population. The median UIC can also be used to indicate the severity of deficiency, for example a population with median UIC <20µg/L is considered severely deficient and moderately deficient if it is 20-49µg/L [1].

Ethical Clearance:

Ethical clearance and approval for this study were obtained from the SMHS Ethics and Research Grant Committee and PNG Medical Research Advisory Committee (PNG MRAC). Permission was obtained from the appropriate authorities in Simbu province, Karimui-Nomane district, Sina Sina Yonggomugl district, the authorities in the various schools, heads of households and the parents of the selected children.

RESULTS:

Questionnaires:

A total of 67 households completed the questionnaires in Karimui-Nomane district compared to 25 households in Sina Sina Yonggomugl district. Of the 67 participants that completed the questionnaires in Karimui-Nomane district, 64.2% (43/67) were males and 35.8 % (24/67) were females. The mean age of the 67 participants was 38.0 ±14.2 years, age range was 16.0 to 70.0 years and median age was 36.0 years. For their level of education, 43.3% (29/67) had secondary school education, 37.3% (25/67) completed university, 16.4% (11/67) completed primary school and 3.0% (2/67) could not read or write. A total of 98.5% (66/67) of the participants were married and 1.5% (1/66) was single. For their employment status, 95.5% (64/67) were unemployed and 4.5% (3/67) were employed. One of the major reasons for the low employment rate is because of the remoteness of the district.

The participants in Sina Sina Yonggomugl were comparable except many more were female and less were married. The mean age of all the 25 participants in Sina Sina Yonggomugl was 37.7 ± 13.3 years, age range was 21.0 to 78.0 years and median age was 35.0 years. There were 7 (28.0%) male and 18 (72.0%) female participants. 52.0% (13/25) of the participants had primary school level education, 36.0% (9/25) had secondary school level education and 12.0% (3/25) completed university. For marital status, 76.0% (19/25) were married, 16.0% (4/25) were single and 8.0% (2/25) were widows. All the 25 participants were unemployed. No specific reasons could be given for the low employment rate.

Knowledge, awareness and practices related to the use of iodized salt:

The participants in the 67 households in Karimui-Nomane and the 25 households in Sina Sina Yonggomugl districts stated yes to the question “Do you use salt at home?” In Karimui-Nomane 14.9% (10/67) used the salt for cooking only, and 85.1% (57/67) use salt for cooking and adding to food before eating.

When asked if they use iodized salt at home, 52.2% (35/67) were positive that they use iodized salt at home, 1.5% (1/67) said they do not use iodized salt at home and 46.3% (31/67) was not sure. 77.6% (52/67) had no knowledge about why it is important to use iodized salt. 34.3% (23/67) said they always purchase salt from the local markets, 58.2% (39/67) purchase salt from the supermarkets, and 7.5% (5/67) purchase from the local markets and trade stores.

When asked how often they eat food from the sea, 17.9% (12/67) said frequently, 58.2% (39/67) said once in a while and 23.9% (16/67) admitted that they have never consumed food from the sea. None of the participants responded to the question regarding the use of traditional salt, including water from the salt stream.

In Sina Sina Yonggomugl district 16.0% (4/25) used the salt for cooking only, and 84.0% (21/25) use salt for cooking and adding to food before eating.

When asked if they use iodized salt at home, 92.0% (23/25) were positive that they use iodized salt at home, 4.0% (1/25) said they do not use iodized salt at home and 4.0% (1/25) was not sure if they use iodized salt at home. 88.0% (22/25) had no knowledge about the use of iodized salt. 36.0% (9/25) said they always purchase salt from the local markets and 64.0% (16/25) purchase salt from the supermarkets and other shops.

When asked how often they eat food from the sea, all the participants (100%) admitted that they have never consumed food from the sea. The participants did not respond to the question about the use of traditional salt at home.

Salt Consumption and Iodization (**process indicator**):

Availability of salt in households:

In each district 50 households participated in this section of the study. Each household was visited twice. At the time of the first visit salt was available in 17 (34.0%) of the 50 households in Karimui-Nomane district, and in 36 (72.0%) of the 50 households in Sina Sina Yonggomugl district. A teaspoon of salt was collected from each household where salt was available.

Iodine content in salt from the households:

The summary statistics of the iodine content (ppm) in the salt samples collected from the households are presented in Table 1.

The mean (± STD) iodine content in salt samples from households in Karimui-Nomane was 34.7 ± 13.4ppm and the range was 1.9 – 64.7ppm; for salt samples from Sina-Sina Yonggomugl the mean iodine content was 32.7 ± 10.5ppm and the range was 2.0 – 62.6ppm.

The Iodine content was below 30.0ppm in 3 (17.6%) of the 17 salt samples from households in Karimui-Nomane and 13 (36.2%) of the 36 salt samples from households in Sina-Sina Yonggomugl districts indicating that 82.4% and 63.8% of households with salt at the time of the survey in Karimui-Nomane and Sina-Sina Yonggomugl districts had adequately iodized salt. In both districts, the iodine content in was below 15ppm in only one sample.

Iodine content in water from salt stream in Karimui-Nomane district:

The iodine content was zero in the two water samples collected from the salt water stream in Karimui-Nomane district at the time of this study.

Table 1: Summary statistics of Iodine content (ppm) in salt samples collected from the households in the two districts

Parameters	Karimui-Nomane	Sina Sina Yonggomugl
Salt available	17 (34%)	36 (72%)
Mean (ppm)	34.7	32.7
Std Dev (STD)	13.4	10.5
95% Confidence Interval (95% CI) (ppm)	27.8 – 41.6	29.2 – 36.3
Range (ppm)	1.9 – 64.7	2.0 – 62.6
Median (ppm)	33.5	33.0
Interquartile Range (IQR)	30.7 – 39.9	27.4 – 36.9
Number (%) of salt with Iodine content<30ppm	3 (17.6%)	13 (36.2%)
Number (%) of salt with Iodine content ≥30ppm	14 (82.4%)	23 (63.8%)
Number (%) of salt with iodine content <15ppm	1 (5.9%)	1 (2.8%)

Table 2: Summary statistics of the discretionary intake of salt per capita per day in both districts

Parameters	Karimui-Nomane	Sina Sina Yonggomugl
N	47	39
Mean (g)	4.62	6.0
Standard Deviation (STD)	0.42	2.61
95% Confidence Interval (95% CI) (g)	3.78 – 5.48	5.15 – 6.85
Range (g)	0.30 – 14.20	1.6 – 11.9
Median (g)	3.80	5.80
Interquartile Range (IQR) (g)	2.80 – 6.75	4.1 – 7.75

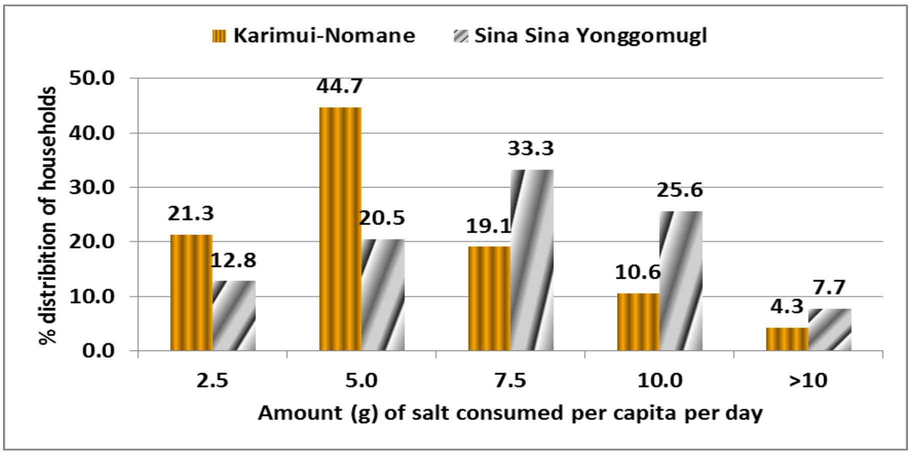

Fig. 2: Frequency (%) distribution of the per capita discretionary intake of salt per day in households in Karimui-Nomane and Sina Sina Yonggomugl districts

Discretionary intake of salt per capita per day:

The summary statistics of the discretionary intake of salt per capita per day in Karimui-Nomane and Sina Sina Yonggomugl districts are presented in Table 2. While 50 households in each district were given a package of salt in order to assess discretionary intake, only 47 households from Karimui-Nomane and 39 from Sina Sina Yonggomugl gave permission for the package to be weighed at the time of the second visit. In Karimui-Nomane district the mean per capita discretionary intake of salt was 4.62 ± 0.42 g/day and the range was 0.3 – 14.2 g/day. In Sina Sina Yonggomugl district the Mean was 6.0 ± 2.61g/day and range was 1.6 – 11.9 g/day. The Mann-Whitney U and Wilcoxon W tests indicate statistically significant difference (p = 0.01. two-tailed) between the discretionary daily per capita intake of salt in households in Karimui-Nomane district compared to Sina Sina Yonggomugl district. Similar results were obtained using the Kruskal Wallis and Chi-Square tests (p = 0.011).

The frequency distributions of the discretionary per capita consumption of salt per day in households in Karimui-Nomane and Sina Sina Yonggomugl districts are presented in Fig. 2. In Karimui-Nomane district the discretionary consumption of salt per capita per day was up to 5.0g in 66.0% (31/47) of the households compared to 34.0% (16/47) consuming over 5.0g of salt. This was in contrast to the results for households in Sina Sina Yonggomugl where 33.3% (13/39) of the households were consuming up to 5.0g of salt per capita per day compared to 66.7% (26/39) consuming over 5.0g of salt.

Estimated intake of iodine per capita per day:

The mean discretionary intake of salt per capita per day in households in Karimui-Nomane district was 4.62 ± 0.42g. The mean iodine content in the salt from the households was 34.7 ± 13.4ppm. Thus, the calculated mean discretionary intake of iodine per capita per day was 160.3 ± 14.6µg. Assuming that 20.0% of iodine in the salt was lost during storage and food preparation, the calculated per capita discretionary intake of iodine was 128.2 ± 11.7µg per day.

For households in Sina Sina Yonggomugl district, the mean discretionary intake of salt was 6.0 ± 2.61g; the mean iodine content in salt was 32.7 ± 10.5ppm. The calculated mean discretionary intake of iodine per capita per day was 196.2 ± 85.3µg per day. Assuming 20.0% of iodine was lost in the salt during storage and food preparation, the calculated per capita discretionary intake of iodine was 157.0 ± 68.2µg per day.

URINARY IODINE CONCENTRATION (impact indicator):

For the assessment of iodine status, 301 children were randomly selected from 7 schools in Karimui-Nomane district and 261 children from 3 schools in Sina Sina Yonggomugl district. Casual urine samples were collected from 293 children in Karimui-Nomane and 252 children in Sina Sina Yonggomugl districts. These gave non-response rates of 2.7% in Karimui-Nomane and 3.4% in Sina Sina Yonggomugl districts.

The distributions of the UIC for the 291 children in Karimui-Nomane and 253 children in Sina Sina Yonggomugl are presented in the Box-plots in Fig 3. The Box-plots show that the UIC (µg/L) data were not normally distributed. This was confirmed by the Shapiro-Wilks tests (p = 0.001) for normality of distribution. Thus, non-parametric statistics were used for further analysis of the UIC data.

The summary statistics of the UIC (µg/L) for the 291 and 253 children in Karimui-Nomane and Sina Sina Yonggomugl districts respectively are presented in Table 3. For children in Karimui-Nomane the median UIC was 17.5µg/L and the interquartile range (IQR) was 15.0 – 43.0µg/L. In addition, 97.3% (283/291) of the children had UIC less than 100.0µg/L and 77.7% (226/291) had UIC below 50.0µg/L.

For the children in Sina Sina Yonggomugl, the median UIC was 57.5µg/L and the IQR was 26.3 – 103.0µg/L. 73.1% (185/253) had UIC below 100.0µg/L and 41.5% (105/253) had UIC below 50.0µg/L.

The Mann-Whitney U and Wilcoxon W tests indicated statistically significant difference (p = 0.001, 2-tailed, Z = - 9.847) between the UIC of the children in the two districts. This was further confirmed by the Kruskal Wallis and Chi-Square tests (p = 0.001).

The median UIC values of 17.5ug/L and 57.5ug/L for the children in Karimui-Nomane and Sina Sina Yonggomugl districts indicate severe and mild iodine deficiency respectively.

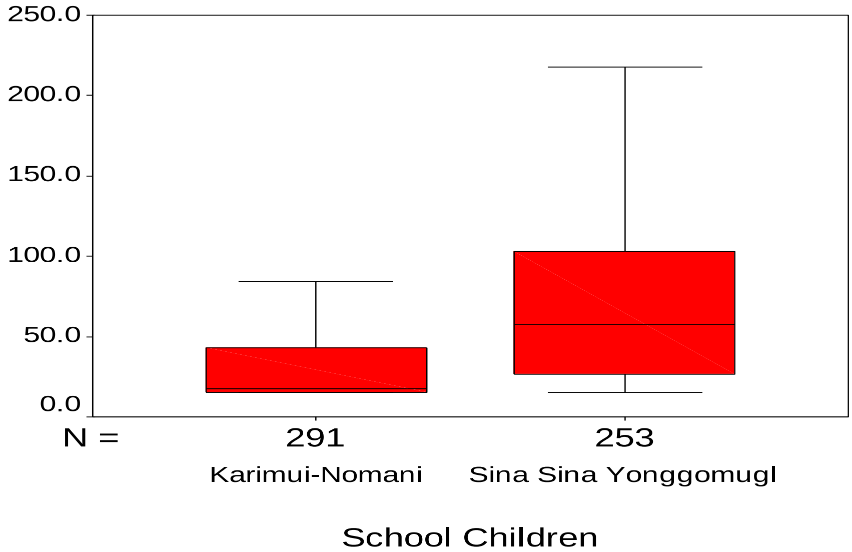

Fig. 3: Box-plots of urinary iodine concentrations (µg/L) in school children from Karimui-Nomane and Sina Sina Yonggomugl districts

Table 3: Summary statistics of urinary iodine concentration (µg/L) for the school children in Karimui-Nomane and Sina Sina Yonggomugl districts

	Karimui-Nomane	**Sina Sina Yonggomugl**
Parameters	**All children (n = 291)**	**All children (n = 253)**
Median (µg/L)	**17.5**	**57.5**
IQR (µg/L)	**15.0 – 43.0**	**26.0 – 103.0**
Mean (µg/L)	33.1	72.5
Std Dev	27.2	83.3
95% CI (µg/L)	29.9 – 36.2	62.2 – 82.8
Range (µg/L)	15.0 – 135.5	15.0 - 217
Percent (n) of children with UIC< 100µg/L	**97.3% (283)**	**73.1% (185)**
Percent (n) of children with UIC< 50µg /L	**77.7% (226)**	**41.5% (105)**

For further analyses of the UIC data the children were separated according to gender. Gender was not indicated in 8 (2.7%) of the 291 urine samples from Karimui-Nomane district and in 9 (3.6%) of the 253 urine samples from Sina Sina Yonggomugl district. Of the urine samples from Karimui-Nomane, 55.8% (158/283) were from male and 44.2% (125/283) from female children. For urine samples from Sina Sina Yonggomugl district 56.6% (138/244) from male and 43.4% (106/244) from female children.

Fig 4 show the Box-plots for the UIC (µg/L) obtained for the male and female children in both districts. The results indicate that the UIC were not normally distributed, which were confirmed by the Shapiro-Wilks tests for normality of distribution (p = 0.001).

The summary statistics of the UIC (µg/L) for the male and female children in Karimui-Nomane and Sina Sina Yonggomugl districts are presented in Table 4. The median UIC for the male and female children in Karimui-Nomane district was 16.5µg/L and 15.5µg/L respectively; the IQR for the male children (15.0 – 42.0µg/L) was similar to that of female children (15.0 – 42.0µg/L). There was no statistically significant difference (p = 0.751, 2-tailed) between the UIC for the male and female children in Karimui-Nomane district.

For the male children in Sina Sina Yonggomugl, the median UIC was 61.3µg/L and the IQR was 25.1 – 108.1µg/L; for the female children, the median was 53.5µg/L and IQR was 26.3 – 93.6 µg/L. The UIC for the male children was not significant different (p=0.182, 2-tailied) from those of the female children.

The UIC for the male and female children in Karimui-Nomane district were significantly lower than the UIC for the male (p = 0.001, 2-tailed) and female (p = 0.001, 2-tailed) children in Sina Sina Yonggomugl district.

Fig. 4: Box-plots of UIC for male and female school children in Karimui-Nomane and Sina Sina Yonggomugl districts Simbu Province

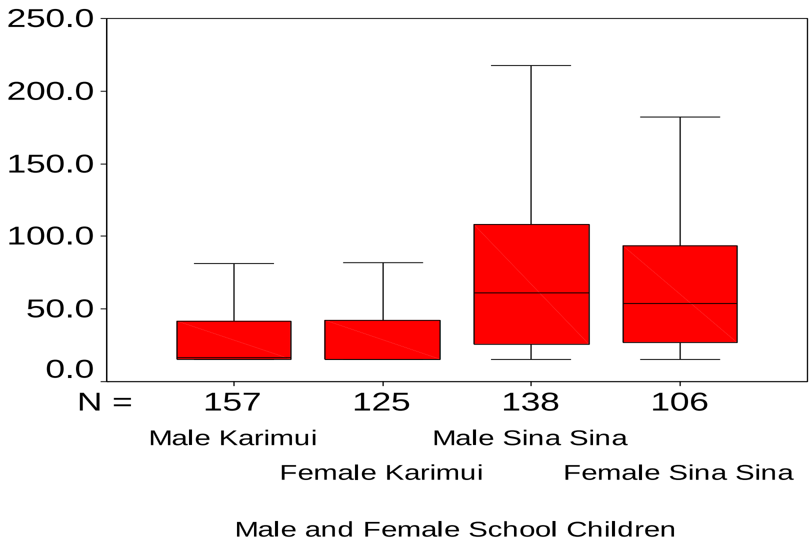

Table 4: Summary statistics of the UIC (µg/L) for the male and female school children in Karimui-Nomane and Sina Sina Yonggomugl districts

	Karimui-Nomane		Sina Sina Yonggomugl	
Parameters	**Male children (n =158)**	**Female children (n = 125)**	**Male children (n = 138)**	**Female children (n = 106)**
Median (µg/L)	**16.5**	**15.5**	**61.3**	**53.5**
Interquartile Range (IQR) (µg/L)	**15.0 – 42.0**	**15.0 – 42.0**	**25.1 – 108.1**	**26.3 – 93.6**
Mean (µg/L)	32.3	32.9	81.0	63.1
Std Dev	26.0	28.4	105.1	44.0
95% CI (µg/L)	28.2 – 36.4	27.9 – 37.9	63.3 – 98.7	54.7 – 71.6
Range (µg/L)	15.0 – 135.5	15.0 – 132.0	15.0 – 217.5	15.0 – 182.0
Percent (n) of children with UIC below 100µg/L	**97.5% (154)**	**96.8% (121)**	**67.4% (93)**	**81.1% (86)**
Percent (n) of children with UIC below 50µg/L	**77.8% (123)**	**80.0% (100)**	**37.0% (51)**	**45.3% (48)**

For the male and female children in Karimui-Nomane district, median UIC of 16.5µg/L and 15.5µg/L respectively indicate severe iodine deficiency and insufficient intake of iodine. For the male and female children in Sina Sina Yonggomugl district, median UIC of 61.3µg/L and 53.5µg/L respectively indicate mild status iodine deficiency and insufficient intake of iodine.

DISCUSSION:

All the participants in both districts that completed the questionnaires stated that "they use salt at home", supporting the global norm that everyone eats salt, and premise of the salt iodization strategy that salt is a good vehicle for iodine fortification. However, when asked if salt was available, only 34% said 'yes' in Karimui-Nomane and only 72% in Sina Sina Yonggomugl. This is much lower than the global norm and may indicate that salt is less appropriate as a fortification vehicle in some areas of PNG. Use of salt may be low in some areas of PNG because availability of commercial salt is constrained by remoteness and distance from ports, as the majority of salt is imported, and/or because of the availability of "traditional salt" such as the salt stream reported in Karimui-Nomane district. According to anecdotal reports, in some areas in Karimui-Nomane district, two practices are used; water from the salt stream is sprinkled on food for taste or grass is soaked in the water from the salt stream then allowed to dry before being incinerated and the ash used as salt on foods.

In households where salt was available however, almost all was iodized above 15ppm (94.1% and 97.2% in Karimui-Nomane and Sina Sina Yonggomugl respectively), and the majority was iodized above 30ppm, the national standard (82.4% and 63.8% respectively). Other studies in PNG have found similar high rates of adequate salt iodization in households; 95.0% in Hela district in 2004 [8], 94.5% in National Capital District (NCD) in 2006 [10], 95.0% in NCD in 2009 [11] and 78.0% in Morobe and Eastern Highlands Provinces in 2013 [12].

This study found discretionary salt intake to be relatively low in the two districts studied, at around 5g per capita per day, compared to an estimated global average of 10.06g [21]. Moreover, this study's estimate might be an over-estimation as it is based on the amount of salt consumed from packages provide free to the households during the survey. It is possible that the households may have consumed more than they normally would when they have to purchase the salt themselves. However, studies in other parts of PNG have also recorded relatively low and even lower salt consumption; 6.59g in Lae city, Morobe province [7]; 2.62g in Hela province [8]; and 4.7g in Morobe and Eastern Highlands provinces [12]. Nevertheless, despite the low discretionary salt intake in PNG, at current levels of iodization, it would provide sufficient amount of iodine of 150ug/person/day [1] to prevent deficiency and salt iodization would be expected to be highly effective.

However, salt with iodine content above 30ppm was available in only 28.0% (14/50) and 46.0% (23/50) of selected households in Karimui-Nomane and Sina Sina Yonggomugl districts respectively. Thus, according to the PNG salt legislation only 28.0% and 46.0% of randomly selected households in Karimui-Nomane and Sina Sina Yonggomugl districts respectively had adequately iodized salt at the time of this study [4, 5]. These values are lower than the 90.0% recommended coverage of households with adequately iodized salt that should indicate effective implementation of the USI strategy in both districts.

Our data indicate that salt iodization is unlikely to be effective in these two districts in Simbu province, and indeed, school age children in both districts were found to be iodine deficient. Unlike in other countries where salt iodization levels and even non-iodization is the limiting factor to effectiveness of salt iodization, in PNG availability of salt may be the limiting factor. Data on salt availability in PNG is limited. As already reported, 38% of households sampled for the National Nutrition Survey of 2005 had no salt on the day of the data collection; this proportion was as high as 50% in the Southern region and between 32% and 36% in the remaining regions; it was 42% in rural areas [6]. A survey in Kerema district in Gulf province found 35% of households had no salt in 2015 [14]. Paradoxically, the National Nutrition Survey found iodine status to be adequate in all four regions of PNG however. This may be because while salt was not available in a large proportion of households on the day of the survey, it was available in these households both before and after the day of the survey, i.e. the whole population is benefiting from salt iodization even though there may be days when they have no salt, or the population urinary iodine data, which is based on the median urinary iodine concentration from the whole population, is hiding pockets of deficiency in sub-populations with the lowest availability of salt.

The results of this survey, combined with other data on salt availability and iodine status from PNG, suggest a unique situation and an urgent need for a better understanding on salt availability and iodine status of sub-populations in the country if the severe consequences of iodine deficiency on the health of the women and children [1 – 3] are to be avoided. It may be that for the country as a whole, or for certain sub-populations in PNG, salt iodization is not an effective strategy, even when properly implemented, and an alternative or complementary strategy to increase iodine intake is needed. Potential alternative or complementary strategies are fortification of an alternative food vehicle, such as rice or wheat flour, [22] or targeted distribution of iodine supplements to high risk groups [24]. It is possible however that those communities in which access to salt is low do not have access to another processed food that could be a suitable food vehicle for iodization and the lack of roads may also be a limiting factor to achieving high coverage of iodine supplements.

School children in the 6 – 12 years age group are recommended for the assessment of iodine nutrition in a population because of their easy accessibility in the community and the iodine status is assumed to reflect the iodine status of other members of 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 Karimui-Nomane and Sina Sina Yonggomugl districts [1, 15, 18].

The response rates of 97.3% and 96.6% obtained in Karimui-Nomane and Sina Sina Yonggomugl districts are higher than values reported for similar studies in other districts in PNG [7, 8, 10 – 13].

The median UIC for the children in Karimui-Nomane district (17.5µg/L) indicates insufficient iodine intake and severe iodine deficiency. For the children in Sina Sina Yonggomugl district, the median UIC (57.5µg/L) indicates mild iodine deficiency. Thus, iodine deficiency should be considered as significant public health problem among schoolchildren, age 6 – 12yrs, in both districts at the time of this study. This should be of great concern to program planners in the districts, Simbu province, Highlands region and the National Health Department (NDoH).

The median UIC for children in Sina Sina Yonggomugl was higher than the value reported for schoolchildren in Southern Highlands Province PNG (48.0ug/L) [7], but lower than the value reported in Honduras (287ug/L), Nicaragua (259ug/L), El Salvador (251ug/L), Chile (565ug/L), Ecuador (590ug/L), Brazil (1013ug/L) and Mexico (1150ug/L) [23].

In Karimui-Nomane the UIC for 77.8% (123/158) of the male and 80.0% (100/125) of the female children was below 50.0µg/L. These values were higher than the 37.0% (51/138) for the male and 45.3% (48/106) for the female children in Sina Sina Yonggomugl district. The median UIC values obtained show that the situation in both districts should be considered critical among the male and female children in the 6 to 12 years age groups at the time of this study. The situation is more critical in Karimui-Nomane district compared to Sina Sina Yonggomugl district.

CONCLUSIONS:

The present study found low coverage of adequately iodized salt and iodine deficiency in school children in two districts of Simbu province, in contrast to the national level data (albeit from 2005) indicating adequate iodization levels of salt in households with salt, and iodine sufficiency at national level. Rather than suggesting a decline in the iodization situation and a subsequent decline in iodine status since 2005, we believe our present study confirms the existence of some communities in PNG which are not easily accessible by road and which, therefore, are at high risk of iodine deficiency, because of low availability of salt. Unfortunately, the risk of iodine deficiency may not be alleviated by improved implementation of salt iodization or education on the importance of iodized salt, because neither of these strategies will address the fundamental problem of salt availability. Rather, it is necessary to ascertain the existence of communities whose access to salt is so constrained as to make salt iodization ineffective, and, if such communities do exist, to identify alternative or complementary strategies in order to increase iodine intake in these communities.

ACKNOWLEDGEMENTS:

The funding for this project was by the UNICEF through the Papua New Guinea National Department of Health (PNG NDOH). The findings and conclusions in this manuscript are those of the authors; they do not represent the official position of the institutions and organizations of the authors. We acknowledge the support of the Chief Technical Officer and other technical staff members in the Division of Basic Medical Sciences, School of Medicine and Health Sciences, University of PNG.

All the authors declare no conflicts of interest.

REFERENCES:

1. WHO, UNICEF, ICCIDD. Assessment of IDD and monitoring their elimination: A guide for program mangers 3rd Edition; WHO/NHD/01.1, 2007.
2. MB Zimmermann and K Boelaert, Review: Iodine deficiency and thyroid disorders www.thelancet.com/diabetes-endocrinology Published online January 13, 2015 http://dx.doi.org/10.1016/S2213-8587(14)70225-6.
3. WHO. Guideline: fortification of food-grade salt with iodine for the prevention and control of iodine

deficiency disorders. Geneva: World Health Organization; 2014. www.who.int/nutrition/publications/guidelines/fortification_foodgrade_saltwithiodine/en/

4. Barter P. Pure Food Act (chap. 232) amendment of Pure Food Standards. Papua New Guinea National Gazette, Port Moresby 1995; G47.
5. Papua New Guinea National Department of Health, Food Sanitation Regulation, Statutory Instrument No. 01, Port Moresby 2007.
6. Papua New Guinea National Nutrition Survey 2005, Chapter 5; Pac J Med Sci. Vol. 8, No. 2, May 2011; 54–59. http://www.pacjmedsci.com/vol8no-22011pngnns.htm
7. Amoa B, Pikire T, Tine P. Iodine content in salt in Lae city of Papua New Guinea. Asia Pacific J. Clin Nutr(1998) 7 (2):128-130.
8. Temple VJ, Mapira P, Adeniyi KO, Sims P. Iodine deficiency in Papua New Guinea (Sub-clinical iodine deficiency and salt iodization in the highlands of Papua New Guinea). J of Public Health, 2005, 27: 45 – 48.
9. Temple VJ. “Progress towards elimination of IDD in PNG” International Council for Control of Iodine Deficiency Disorders. IDD Newsletter, Vol. 22, No 4, Nov. 2006; 11 – 13.
10. Temple VJ, Haindapa B, Turare R, Masta A, Amoa AB and Ripa P. Status of Iodine Nutrition in Pregnant and Lactating Women in National Capital District, Papua New Guinea. Asia Pacific Journal of Clinical Nutrition, 2006; 15 (4): 533 – 537.
11. Temple VJ, Oge R, Daphne I, Vince JD, Ripa P, Delange F and Eastman CJ. “Salt Iodization and Iodine Status among Infants and Lactating Mothers in Papua New Guinea” AJFAND, Vol 9, No. 9, Dec 2009, 1807 - 1823
12. Lomutopa SJ, Aquame C, Willie N and VJ Temple. Status of Iodine Nutrition among School-age Children (6 – 12 years) in Morobe and Eastern Highlands Provinces, Papua New Guinea, Pacific J. Medical Sciences 2013, Vol. 11, No. 2, 70 – 87.
13. Temple VJ and K Codling. Papua New Guinea’s Commitment to USI Pays Off. IDD Newsletter. May 2015 Available at: http://ign.org/newsletter/idd_may15_papua_new_guinea.pdf Accessed on 25th October, 2015
14. Goris JM, Zomerdijk N and VJ Temple. Nutritional status and dietary diversity of Kamea in Gulf Province, Papua New Guinea; Asia Pacific Journal of Clinical Nutrition (APJCN), 2017, Vol. 26 (4): 665 – 670. (doi: 10.6133/apjcn.052016.09 Published online: May 2016, 1 – 14).
15. Pediatric Society of PNG: Midterm Consultative meeting reports; Port Moresby General Hospital, June 2014 and 2015; Port Moresby, Papua New Guinea (Unpublished).
16. De Sanctis V, Di Maio S, Soliman AT, Raiola G, Elalaily R and G Millimaggi. Hand X-ray in pediatric endocrinology: Skeletal age assessment and beyond. Indian J Endocrinol Metab 2014 Nov; 18 (Suppl. 1): S63 – S71. Doi: 10.4103/2230-8210.145076.
17. Patidar PP, Philip R, Toms A, Gupta K. Radiological manifestations of juvenile hypothyroidism. Thyroid Res & Pract, 2012; 9: 102 – 104.
18. PNG National Statistics: Highlands Region: Simbu Province; www.nso.gov.pg/index.php/population-and-social/other-indicators#highlands-region
19. Bartlett JE, Kotrlik JW, Higgins CC. Organizational research: determining appropriate sample size in survey research. Inform Tech Learn Perform J 2001;19:43-50.
20. WYD Iodine Checker. Instruction manual: Salt research institute. China National Salt Industry Corporation: 1 – 10.
21. Powles J, Fahimi S, Micha R, Khatibzadeh S, Shi P, Ezzati M, Engell RE, Lim SS, Danaei G and D Mozaffarian. Global, regional and national sodium intakes in 1990 and 2010: a systematic analysis of 24 h urinary sodium excretion and dietary surveys worldwide. BMJ Open 2013
22. Land MA, Christoforou A, Downs S, Webster J, Billot L, Li M, Peña-Rosas JP, Neal B. Iodine fortification of foods and condiments, other than salt, for preventing iodine deficiency disorders. Cochrane Database of Systematic Reviews 2013, Issue 9. Art. No.: CD010734. DOI: 10.1002/14651858.CD010734.
23. Pretell EA, Delange F, Hostalek U, Carigliano S, Barreda L, Higa MA, Altschuler N, Barragan D, Cevallos JL, Gonzales O, Jara JA, Medeiros-Neto G, Montes JA, Muzzo S, Pacheco M, and Cordero L. Iodine Nutrition Improves in Latin America. Thyroid, Vol. 14, No. 8, 2004; 590 – 599
24. WHO and UNICEF. Reaching Optimal Iodine Nutrition in Pregnant and Lactating Women and Young Children: Joint Statement by the World Health Organization and United Nations Children’s Fund. World Health Organization, 2007.