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Iodine deficiency in Papua New Guinea (sub-clinical iodine deficiency and salt iodization in the highlands of Papua New Guinea)

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Abstract

Data on the status about iodine nutrition in children in Papua New Guinea (PNG) are scarce. This study attempts to determine the mean daily per capita consumption of salt, the iodine content of salt in the households and retail shops and the urinary iodine concentration in children (6–12 years) in Hella Region, Southern Highland Province (SHP), PNG. The mean daily consumption of salt was 2.62 ± 1.29 g. The iodine content of salt was >30 p.p.m. in 95 per cent of households and 100 per cent of retail shops. The median urinary iodine concentration of 48.0 mg/l for all the children indicates moderate iodine deficiency. The median urinary iodine concentrations for the male (67.0 mg/l) and female (44.0 mg/l) children indicate mild and moderate iodine deficiency, respectively. 68.42 per cent of the male and 81.82 per cent of the female children have urinary iodine concentration <100 mg/l, indicating that iodine deficiency is a potential public health problem in the Hella region. These results indicate a need for further assessment of the implementation of the universal salt iodization strategy for the elimination of iodine deficiency in the SHP, PNG.

Keywords: Papua New Guinea, Hella, iodized salt, urinary iodine

Introduction

The harmful effects of iodine deficiency disorders (IDD) are manifold, depending on the severity of iodine deficiency.[1–3] Iodine deficiency is the world's greatest single cause of preventable mental retardation.[4] Marginal degrees of iodine deficiency that affect many apparently healthy children can impair their mental and motor functions.[1–4] The manifestations range from small neurological changes, to impaired learning ability and underperformance in school, including poor performance in psychometric tests.[2–4]

Universal salt iodization (USI) is the main intervention strategy for the control and elimination of IDD in an affected population.[2,4] Successful implementation of USI requires constant monitoring to ensure that the iodine content in the salt is at the appropriate level at the time of consumption. Median urinary iodine concentration is an important indicator that can be used to assess the iodine status in a population.[2,3]

In order to control IDD and to comply with the international goal of USI,[2,4] the Government of Papua New Guinea (PNG) amended the pure food act in June 1995, banning the importation and sale of non-iodized salt.[5] According to the amendment, all salts used in PNG must be iodized with potassium iodate and the iodine content should not be <30 p.p.m.[5] Since the promulgation of the amendment there has been no indication of any systematic monitoring of its implementation, and no baseline data have been available on the iodine status of children in PNG.

This study aimed to assess the status of salt iodization and iodine nutrition, in Hella Region, Southern Highland Province (SHP), PNG. The principal aims were to determine the per capita consumption of salt, the iodine content of salt in the households and retail shops and the urinary iodine concentration in children (6–12 years) in Hella Region, SHP, PNG.

Materials and methods

South Highlands Province (SHP) has a population of 317 437 and the Hella region 101 580.[6] The study was conducted in the Hella region (Tari and Koroba districts) in the SHP, PNG. The Hella region is located at an altitude of between 1500 and 2100 m above sea level.[7] The communities are clustered into villages/settlements around some 55 schools. The school/community was chosen as the sampling frame and 10 schools and their associated communities were randomly selected-approximate total population of 20 000 people. A cluster, drawn on three

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separate occasions, was then sampled for children, for salt samples and salt distribution. It is estimated that there are about 3000 children between the ages of 6 and 12 years in this population cluster of 10 schools/communities (Table 1).

In each of 10 schools, 30–40 children were randomly selected for urinary iodine samples to provide a child population of 350 (the child sampling fraction was a little over 10 per cent of the children available for sampling in the 10 communities). In the same way 20 of the 55 communities were randomly selected and 10–14 households randomly selected for salt distribution. This provided some 281 households. Finally, a different 20 of the 55 communities were randomly chosen and one or two households selected, in each, to provide some of their domestic salt for analysis of iodine content. 40 samples were so obtained.

Thus, the study population includes 281 randomly selected households in Hella region. In addition, 40 of these households were randomly selected and about three tablespoons (approximately 35 g) of the salt available in each household was collected for analysis. Salt samples for analysis were also purchased from retail outlets in the study area.

To estimate the daily salt consumption per person, a standard package of salt was given to each of the 281 households. Each household was re-visited at least once during the 4 weeks of data collection. On each occasion the salt package was reweighed and the number of individuals in each household was recorded.

The concentration of iodine in the salt samples collected from each household and those purchased from retail outlets was determined using the standard iodometric titration procedure recommended by the ICCIDD.[2,8]

The study population for urinary iodine consisted of 350 (6–12 years old) school children, both boys and girls, from 10 schools selected randomly from the more than 50 schools in the Hella region. Children in this age group were selected for the study based on the WHO, UNICEF and ICCIDD recommendation.[2,8] Between 30 and 35 urine samples were collected in each of the 10 schools in the morning during school hours. From each child, about a 5–10 ml casual urine sample was collected in wide-mouth screw-capped plastic bottles. One drop of toluene was added to each sample to inhibit bacterial growth and to minimize odour.[8] The samples were then stored frozen until analysis.

Table 1 Populations and sampling

Southern Highlands Province: 317 437
Hella region: 101 580
55 Schools/communities in Hella region: 1800–2000 people in each cluster
10 Schools/clusters selected for school sampling
Approximate population: 20 000
Children age 6–12 years population about: 3000
Children sampled: 350
20 Communities/clusters selected for households
Salt distribution: 281 households
20 Communities for salt collection and analysis: two salt samples collected per community: 40 salt samples

The collection of urine samples was completed before the distribution of iodized salt packages for subsequent calculation of per capita consumption of salt.

The urinary iodine concentration was determined using the sensitive spectrophotometric method of Sandell-Kolthoff reaction after digesting the urine with ammonium persulphate in a water bath at 100 °C.[2,8] The sensitivity (10.0–12.50 mg/l) and percentage recovery (95 ± 10 per cent) of the UI assay were frequently used to assess the performance characteristic of the assay method.

Results were analysed using the Excel 2000 data analysis package and the EP Info 2002 package. Student's *T*-test was used to assess the statistical significance of the results.

Approval for the study was obtained from the Ethical and Research Grant Committees of the School of Medicine and Health Sciences, University of Papua New Guinea and the local authorities in the Hella Region SHP, PNG.

Results

Salt samples (between 20 and 30 g) were collected from each of the 40 households (response rate, 100 per cent). In about 15 (37.5 per cent) of the households this amounted to collecting all the salt in the house. Table 2 depicts the amount of adequately iodized salt (≥30 p.p.m.) at the household and retail shops.

The mean daily per capita consumption of salt was 2.62 g (SD ± 1.29 g) with a median value of 2.38 g and the 95 per cent CI: 2.47–2.77 g.

A total of 350 causal urine samples (response rate, 100 per cent) were collected for analysis, but results were obtained for only 284 (81.14 per cent) urine samples. The iodine concentration in the remaining 66 (18.86 per cent) urine samples was practically undetectable.

Analysis of the 284 urine samples showed that the median UI concentration was 48.0 mg/l (95 per cent CI: 60.51–73.13 mg/l), with a mean of 66.82 mg/l (SD ± 54.03). According to the joint criteria of WHO, UNICEF and ICCIDD,[2,9] the results indicate moderate iodine deficiency. Table 3 shows the distribution of the children according to their UI concentration and the status of their iodine nutrition.

Table 2 Iodine content of salt samples from the households and retail shops

Iodine content in salt samples (p.p.m.)	Households No. of salt samples (%)	Retail shops No. of salt samples (%)
Nil	0	0
<30	2 (5%)	0
≥30	38 (95%)	7 (100%)

Table 3 Number of children in the different ranges of urinary iodine concentration ($n = 284$)

Status of iodine nutrition	Range of UI concentration[2,8] (µg/l)	No. of children (%)
Severe	<20	72 (25.35)
Moderate	20–49	78 (27.46)
Mild	50–99	62 (21.83)
Optimal	100–199	64 (22.54)
Risk of IIH	200–299	8 (2.82)
IIH	>300	0

IIH Iodine Induced Hyperthyroidism.

Of the 284 children, 152 (53.52 per cent) were male and 132 (46.48 per cent) were female. The median urinary iodine concentrations in the male and female children (67.0 and 44.0 mg/l, respectively) indicate mild and moderate iodine deficiency. Table 4 shows the mean, 95 per cent CI and standard deviation values for the UI concentration in male and female children. The median UI concentration in the male children was higher ($p < 0.05$) than that in the female children.

The distributions of male and female children according to their UI concentration and iodine nutrition are indicted in Table 5. The number of male children (17.10 per cent) with UI concentration in the severe range of iodine deficiency was significantly less than ($p < 0.05$) the number of female children within the same range (33.33 per cent). More male children (28.29 per cent) have UI concentration in the optimal range of iodine nutrition ($p < 0.05$), compared to the female children (15.91 per cent).

Table 4 Urinary iodine concentration in male and female children aged 6–12 years

	Male ($n = 152$)	Female ($n = 132$)
Median (µg/l)	67.0	44.0
Mean (µg/l)	74.20	58.33
95% CI (mg/l)	65.46–82.94	49.31–67.35
SD	54.51	52.39

Table 5 Number of male and female children in the different ranges of urinary iodine concentration (µg/l)

Status of iodine nutrition	Range of UI concentration[2,8] (µg/l)	Male ($n = 152$) No. (%)	Female ($n = 132$) No. (%)
Severe	<20	26 (17.10)	44 (33.33)
Moderate	20–49	45 (29.61)	35 (26.52)
Mild	50–99	33 (21.71)	29 (21.97)
Optimal	100–199	43 (28.29)	21 (15.91)
Risk of IIH	200–299	5 (3.29)	3 (2.27)
IIH	>300	0	0

Discussion

Ninety-five per cent of household salt and 100 per cent of salt in retail shops were adequately iodized (≥30 p.p.m.) based on the value stipulated in the PNG legislation. Thus, the WHO/UNICEF/ICCIDD criteria for successful implementation of the USI strategy[2,4] seem to be adequately implemented in over 90 per cent of households and of retail shops in the region.

According to the WHO/UNICEF/ICCIDD, the per capita consumption of salt in different countries varies over a wide range, from 3 to 20 g per day.[2,8] The 2.62 ± 1.29 g mean daily per capita consumption of salt in the present study, from salt added in food preparation, falls below the lower limit of 3.0 g. It was also lower than the 10.0 g per capita daily consumption used to formulate the PNG standards for iodine content of salt.[5,10,11] This value was also lower than the 6.59 g salt consumed per person per day in Lae City, PNG.[11]

The low daily per capita consumption of iodized salt in this area is mainly due to cultural reasons. While endemic cretinism and goitre have disappeared from the highlands of PNG it seems that this population is at risk of iodine deficiency, which may be having a deleterious effect upon intelligence. The salt intake of this population is low, probably because the intake of processed foods is low while only a little salt is added to food during preparation. From the cardiovascular perspective, the low salt intake of this population is admirable; perhaps the iodine content in the salt they add to their food should be cautiously increased? Alternatively, one can stress the need to advocate a substantial increase in the use of iodized salt already available in the region.

Median urinary iodine concentration in a population is the recommended impact indicator for assessing salt iodization programmes.[2,3,4,9] According to the joint WHO/UNICEF/ICCIDD expert committee, the goal of eliminating IDD as a public health problem in a population would be achieved, if the median urinary iodine concentration should be at least 100 mg/l, with <20 per cent of values below 50 mg/l.[2,9]

The median urinary iodine concentration (48.0 mg/l) for all the children indicates moderate iodine deficiency and insufficient iodine intake, according to the criteria set by WHO/UNICER/ICCIDD.[2,9] 74.65 per cent of all the children have urinary iodine concentration <100 mg/l. In addition, 52.82 per cent of them have urinary iodine concentration <50 mg/l. These results indicate that iodine deficiency is a potential public health problem among children (6–12 years) in the Hella region, as they fall far short of the WHO/UNICEF/ICCIDD criteria for elimination of IDD as a public health problem.[2,9] It is noteworthy that for 66 samples it was impossible to measure any iodine in the urine, thus the results recorded may underestimate the true problem.

The median urinary iodine concentration for male children (67.0 mg/l) indicates mild iodine deficiency, while that for female children (44.0 mg/l) indicates moderate iodine deficiency, suggesting insufficient iodine intake in both groups of children. 68.42 per cent of the male children and 81.82 per cent of the female children have urinary iodine concentration <100 mg/l. Furthermore, 46.71 per cent of the male children and 59.85 per cent of the female children have urinary iodine concentration <50 mg/l. This strongly suggests that iodine deficiency is a potential public health problem among the male and female children in the Hella region. These findings indicate that iodine deficiency is higher among the female children compared to the male children in the Hella region. These findings support the observations made in several provinces of PNG, where a vast gender difference on the prevalence of goitre was discovered, suggesting that women and/or girls are twice as likely to suffer from iodine deficiency, than men and/or boys.[10,12,13]

Our results indicate that despite the apparent success of the salt iodization programme in the Hella region, large proportions of both male and female children are at risk of developing IDD. One of the reasons for this discrepancy might be due to the dietary habits of the population: they hardly use salt in the preparation of their traditional meals.[14] In addition, there is an apparent lack of awareness of the health benefits of using iodized salt, as indicated by our questionnaire results (unpublished data).

This further strengthens the need for a programme of public education and social mobilization on the significance of IDD and the consumption of the appropriate amount of adequately iodized salt; including a commitment to assessment and reassessment of progress in the elimination of IDD, with regular laboratory data on urinary iodine in school-aged children, with appropriate sampling for high-risk areas.

Conclusion

The prevalence (over 90 per cent) of households and of retail shops with adequately iodized salt indicates a partial fulfilment of the WHO/UNICEF/ICCIDD criteria for the successful implementation of the USI strategy. However, the mean daily per capita consumption of salt is low. Effective and systematic monitoring of the iodine content in salt samples must be maintained, so as to sustain the current level of the implementation of the USI policy. An aggressive awareness campaign on the importance of using the appropriate amount of adequately iodized salt is urgently needed in the region.

The urinary iodine concentration in children (6–12 years) indicates the presence of mild-to-moderate iodine deficiency, based on the criteria set by the WHO/UNICEF/ICCIDD expert committee. This strongly suggests that iodine deficiency is a potential public health problem in Hella region, SHP. The prevalence of iodine deficiency is higher in female children, as compared to the male children. These results indicate a greater need for further assessment of the implementation of the USI strategy for the elimination of iodine deficiency in the SHP of PNG.

There may be further epidemiological work required to measure clinical and sub-clinical thyroid deficiency in this population and possible effects upon brain development and intelligence.

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