PAPUA NEW GUINEA

IFPRI

An Australian Government Initiative

PROJECT NOTE 03 | June 2019

Access to iodized salt in four areas of rural Papua New Guinea

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RESEARCH OVERVIEW

Dietary iodine deficiency results in stunted physical and mental growth in children. Fortifying commercial household salt with a small but adequate amount of iodine is the principal strategy used globally to prevent iodine deficiency. However, there may be barriers to consuming adequately iodized salt for many rural households in Papua New Guinea (PNG). Using results from a rural household survey conducted in four areas of the country with just over 1,000 households in 2018, two issues related to salt iodization in PNG are examined.

First, only about 9 percent of households reported that they did not consume iodized table salt in the seven days prior to being interviewed for the survey. However, specific characteristics are associated with such households. They tend to be located in remote communities, are in the poorest 20 percent of survey households, have no members who received any formal education, and have experienced recent food insecurity. Particularly for remote households, ensuring that their members consume sufficient iodine will require going beyond salt iodization to use other approaches to iodine supplementation.

Second, of the samples of salt obtained from the survey households, the iodine content of two-thirds fell within the PNG regulations, a reasonably encouraging finding. Only about 17 percent of the almost 800 samples obtained had inadequate iodine. However, when the salt samples were examined by brand, it was found that the brand most commonly consumed had the highest share of samples with inadequate iodine levels. Closer monitoring of the iodine content in table salt in PNG and enforcement of salt iodization regulations is required.

INTRODUCTION

Iodine, together with vitamin A, iron, and zinc, is one of the four principal micronutrient deficiencies that are of public health concern globally and in Papua New Guinea. Iodine, although only needed by the body in extremely small amounts, is critical to the production by the thyroid gland of the hormones, thyroxine and triiodothyronine, that regulate many growth functions and metabolic activities of the body. A deficiency of iodine in the diet will result in the thyroid not being able to make the hormones. The most severe consequence of iodine deficiency is stunted physical and mental growth in children that results in significant and generally irreversible intellectual disability. This disorder often stems from iodine deficiency during pregnancy. In addition to affecting fetal growth, maternal iodine deficiency may result in miscarriages and stillbirths. Goiter, an enlargement of the thyroid at the base of the neck, is also commonly seen in individuals who do not consume sufficient iodine.

The underlying cause of iodine deficiency is a scarcity of iodine in the soil on which vegetation grows, animals graze, and crops are cultivated. This results in insufficient iodine in the foodstuffs produced (Eastman and Zimmerman 2018). In contrast, ocean-sourced foods typically contain relatively high levels of iodine (WHO 2014). Fortifying commercial household salt with sufficient iodine to meet dietary needs as the salt is being produced is the principal strategy used globally to prevent iodine deficiency and the adverse health and developmental impacts it causes. Salt is an appropriate vehicle for fortification because it is consumed by virtually everyone almost every day with little seasonal variation, salt production in most countries is quite centralized, adding iodine does not affect the taste or smell of the salt, and fortifying salt with iodine is inexpensive, at a cost of PGK 0.10 to 0.20 per individual per year (WHO 2014).

Universal salt iodization became required by law in PNG with the passage of legislation in 1995. All table salt must have at manufacture or at importation into PNG an iodine content of between 40 and 70 parts per million (ppm) (Barter 1995). The regulations associated with this legislation assume a 30 percent loss in iodine before consumption (NDH 2007). Hence, to be within regulations, the iodine content of table salt in the

household should be between 30 and 50 ppm (Goris et al. 2018).

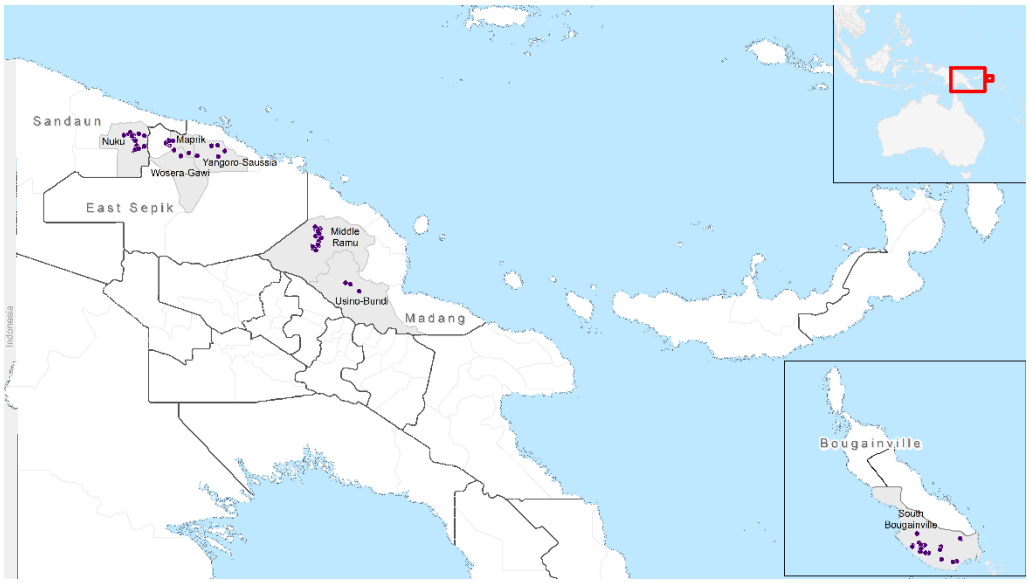
However, many rural communities in PNG are found in remote locations with little access to commercially produced goods, like iodized salt. Moreover, in such isolated communities, education levels are relatively low and access to information on the components of nutritious diets or on other nutrition caring practices is difficult to obtain. Consequently, there may be barriers to consuming adequately iodized salt for many rural PNG households.

Using data from a 2018 survey of over 1,000 households in four rural areas of lowland PNG, this brief reports on an assessment of two issues related to salt iodization in PNG:

- The consumption of packaged table salt by rural households to assess how effective universal commercial salt iodization is likely to be in meeting the iodine requirements of all individuals; and
- Whether the iodine content of the table salt that survey households consume is within the standards of the salt iodization regulations of PNG.

In contrast to more comprehensive studies on the impact of iodized salt consumption on the prevalence of iodine deficiency disorders, no information was collected in the survey on precise levels of individual consumption of iodized salt or on urinary iodine concentration (Goris et al. 2018; Temple et al. 2018). Nonetheless, the challenges in supplying iodized salt to rural households identified through the research presented here can be used to guide changes both to salt iodization strategies and to public health efforts to address iodine deficiency and micronutrient malnutrition more generally in PNG.

Figure 1: Location of survey communities – Papua New Guinea Household Survey on Food Systems, 2018



Source: Based on data from the Papua New Guinea Household Survey on Food Systems, 2018.

THE PAPUA NEW GUINEA HOUSEHOLD SURVEY ON FOOD SYSTEMS, 2018

Between May and July 2018, IFPRI and its partners implemented a household survey in four rural areas of PNG (Figure 1):

- Autonomous Region (AR) of Bougainville – in South Bougainville district in the Siwai and Buin areas at the southern end of the island,
- Madang province – in parts of Middle Ramu and Usino-Bundi districts, a remote area on the Ramu River only accessible by boat,
- East Sepik province – in Maprik, Yangoro-Saussia, and Wosera-Gawi districts near Maprik town or along the main road from Wewak, and
- West Sepik (Sandaun) province – in Nuku district.

The design of the survey involved interviewing 15 randomly selected households in 70 communities selected for enumeration across the four study areas – between 16 and 20 communities in each study area. Two questionnaires were used: a household questionnaire and a community questionnaire that was administered to a small group of leaders in each survey community. The final survey sample consists of 1,026 households.[1]

However, given the challenges of conducting a representative survey in rural PNG, the survey information collected is not representative at the provincial or district level. Communities in the most remote areas of the districts in which the survey

[1] A detailed report on the survey, including specific on the design of the sample, has been published as an IFPRI Discussion Paper - http://www.ifpri.org/publication/papua-new-guinea-survey-report-rural-household-survey-food-systems.

Figure 2: Examples of containers and branded packets from which salt samples were obtained from survey households

Source: PNG Household Survey on Food Systems, 2018

was conducted were not part of the survey strata. Consequently, the analysis here is not weighted and does not necessarily reflect the characteristics of the broader population of any administrative units in which the survey households are found. Nonetheless, the data provide insights into the nutritional challenges facing rural households across a spatially expansive set of communities.

The survey investigated the food systems of the sample households and how they assure sufficient food to meet the nutritional needs of their household members. The household questionnaire focused on agricultural production systems, household livelihoods, and health outcomes and included modules on production; consumption and expenditure; labor activities (farm and non-farm); nutritional status; and the experience of the survey households with recent agricultural production or other shocks that impacted their livelihoods. With the technical support and the provision of field equipment by the UNICEF country office in PNG, anthropometric measurements were made on young children and women of childbearing age in the survey households in order to evaluate their nutritional status.

As an additional component of the nutritional investigations under the survey, all households that reported having consumed table salt as part of their meals in the previous seven days were asked to provide a sample of about one teaspoon of that salt. A photograph was taken of the household salt container and, if possible, the branded packet in which the salt was obtained (Figure 2). The brand name for the salt also was recorded by the survey enumerator. The salt sample, packaged in an individually labeled small polyethylene bag, was sent to the Micronutrient Research Laboratory at the School of Medicine and Health Sciences of the University of Papua New Guinea in Port Moresby for iodine content analysis. The resources necessary for this chemical analysis were kindly provided at no charge by the Micronutrient Research Laboratory and UNICEF-PNG.

The iodine content in the salt samples was measured using a WYD Iodine Checker, which quantitatively measures the iodine content in a substance on the basis of a single wave length photometer. Globally, the instrument has been shown to provide accurate and reliable results for monitoring iodine concentration in salt (Dearth-Wesley et al. 2004). Iodine concentrations in the table salt samples were expressed in ppm. The amount of salt used per assay was 1.0 g. Two assays were made on each sample, and the average of the two results was used in the analysis.

SURVEY ANALYSIS RESULTS

There are two analytical components to the report. First, we examine salt consumption patterns and whether there was salt in the survey household from which a sample could be obtained. Secondly, for those survey households that provided a salt sample, we assess whether the iodine content in the salt in that sample meets the salt iodization standards for PNG.

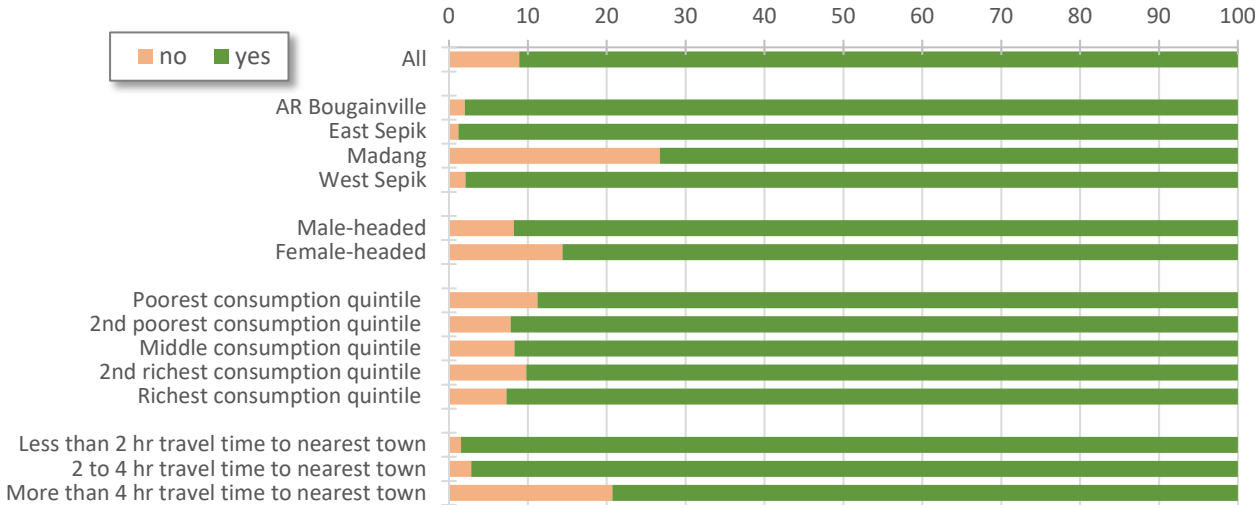
Table salt consumption by survey households

Two different sets of information from the survey are used to examine the salt consumption patterns of the survey households. The first relies on the information provided in the survey questionnaire module on food consumption over the past week. The second approach uses information on whether a sample of table salt was collected from the survey household. We present the results from each analysis in turn.

Salt consumption based on food consumption recall

The survey questionnaire includes a detailed food consumption module used to ask survey respondents whether their household consumed any of 37 separate food items over the previous seven days. Included in the list of food items is “Packaged salt for table & kitchen”. The responses to this question are presented in Figure 3

Figure 3: Consumption of packaged salt for table & kitchen in past seven days, percent of survey households



Source: Analysis of data from the Papua New Guinea Household Survey on Food Systems, 2018.

disaggregated by different categories of survey households. (Traditionally produced salt was not considered in the food consumption module of the survey questionnaire. On such salt, see Box 1 later in this brief.)

Overall, only 91 of the 1,026 survey households (8.9 percent) reported not having consumed packaged table salt in the seven days prior to the day of their being interviewed. However, survey households in Madang province and those that are located more than four hours travel time from the nearest large town are more likely to not have consumed packaged table salt.[2] The survey in Madang province was conducted in remote Middle Ramu district. We also see that households headed by women are less likely to have consumed table salt. No strong association between salt consumption and household welfare, as measured by the value of average daily household consumption per capita, is seen in the figure – while more households in the poorest welfare quintile reported not consuming table salt in the past seven days than households in other welfare quintiles, the difference is not large.

To better understand the household characteristics that are associated with a household not consuming table salt in the past seven day within a multivariate analytical framework, Table 1 presents the results of a logistic regression analysis for which the dependent variable is whether the survey household did not consume table salt in the previous seven days and the explanatory variables are a range of household characteristics.

The coefficients for each explanatory variable in the logistic regression are presented as odds-ratios. The value of the odds-ratio is the chance of the dependent variable changing from 0 to 1 (a positive outcome in statistical terms) as a result of a one-unit positive change in the explanatory variable – that is, in the case here, the chance that the household would not consume table salt with a one-unit change in the explanatory variable. In contrast to the presentation of the results of most regression-based models for which a statistically insignificant coefficient is zero, a statistically insignificant odds-ratio is one – that is, a 1-to-1 or even chance. Statistically significant odds-ratios that are less than one represent an inverse relationship between the independent and dependent variable, while odds-ratios greater than one represent a direct relationship.

Of the 20 household characteristics considered as explanatory variables, only six are shown in the logistic regression to be significantly associated with table salt consumption by the household. Being a female-headed household is not one of these characteristics, despite the pattern seen in Figure 3. Households in the poorest consumption quintile are more likely to not consume table salt than are households in the base category of the middle consumption quintile. Household with no members who attended school are also more likely to not consume salt, compared to the base category of households with members who

[2] Travel time to nearest town was computed using a Geographic Information System that considered the location of the surveyed communities and local major town, land cover and topography, and transportation routes (both roads and rivers). For survey sample households in West Sepik (Sandaun) province, Maprik was considered the closest town; for the East Sepik sample, either Maprik or Wewak; for the Madang sample, Madang town; and for the AR Bougainville sample, Buin.

Table 1: Logistic regression analysis of whether a household did not consume table salt in the past seven days

Dependent variable: Household did not consume table salt in past seven days, 0/1	Odds-ratio	p-value	
Female headed households, 0/1	1.215	0.618	
Household head age under 25 years, 0/1	1.261	0.730	
Household head age 25 to 35 years, 0/1	1.403	0.285	
Household head age 65 years or older, 0/1	0.685	0.498	
Poorest consumption quintile, 0/1	1.997	0.079	*
2nd poorest consumption quintile, 0/1	0.989	0.978	
2nd richest consumption quintile, 0/1	1.247	0.574	
Richest consumption quintile, 0/1	1.211	0.653	
Household size, number	1.013	0.848	
No formal education for any household member head, 0/1	3.878	0.048	**
Secondary or tertiary education highest educational attainment in household, 0/1	0.441	0.002	***
Non-farm activity is household head's primary occupation, 0/1	0.672	0.285	
Household members engage in wage employment, 0/1	1.427	0.464	
Household members engage in non-farm enterprise, 0/1	0.695	0.182	
Household members include a current migrant (still considered part of household), 0/1	0.935	0.845	
Household Dietary Diversity Score, foods consumed in past 24 hours out of 16 food groups	0.882	0.073	*
Worried about household food insecurity in past 4 weeks, 0/1	2.785	0.000	***
Household with child under five years of age, 0/1	0.774	0.436	
2 to 4 hours travel time to nearest town, 0/1	2.329	0.144	
More than 4 hours travel time to nearest town, 0/1	16.043	0.000	***
Constant	0.022	0.000	***
Observations: 1,026; Pseudo R-squared: 0.265			

Source: Analysis of data from the PNG Household Survey on Food Systems, 2018.
Note: * = p < 0.10, ** = p < 0.05, *** = p < 0.01.
Base explanatory variable categories: Age of household head: household head age 36 to 64 years; Consumption-based welfare quintile: middle (third) quintile; Maximum educational attainment in household: primary education; and Travel time to nearest town: less than 2 hours.

attended primary school, but received no higher schooling. In contrast, households with at least one member who received some secondary education are less likely to not consume table salt (statistically significant odds-ratio less than 1.0). Households that have experienced food insecurity are also more likely to be in the group of households that did not consume table salt in the past week, while household with higher diversity in their diets are unlikely to be in that group. Households that are located in the most remote communities surveyed are also much more likely to not have consumed salt in the previous week than are other sample households.

Consumption of table salt by the sample households appears to be associated primarily with the welfare level of the household, educational attainment, household food security, and the degree of access households have to urban centers through which packaged table salt is distributed to markets in their hinterland. The last characteristic on the relative remoteness of the location of the household is likely the most important driver of not consuming table salt, as educational and livelihood opportunities and food security resources also tend to be more restricted in more remote areas.

Salt consumption based on collection of salt samples

If a survey household reported that they consumed table salt in the previous seven days, the respondent was asked to provide a small sample of the salt for testing of its iodine content. However, not all households were able or were willing to provide a sample, even though they reported having consumed table salt. In addition, in transferring the salt samples from the field to the laboratory in Port Moresby, 57 salt samples were misplaced and lost. Table 2 shows the number of households that fall into the different categories based on their provision of and the testing of a table salt sample.

The analysis presented in Table 1 is similar to a comparison of the first category of households listed in Table 2 to households in the other four categories. However, the table salt consumption of households in the second and third categories of Table 2 is also restricted in some way, as evidenced by their inability or unwillingness to provide a small sample of table salt from their household stock. By

Table 2: Table salt samples from survey households – provision of sample and testing of it, percent of households

Household category by salt sample provision	All	AR Bou-gainville	East Sepik	Madang	West Sepik
No prepared table salt consumed in past 7 days (n=91)	8.8	2.0	1.2	26.4	2.1
Consumed salt, but no salt in household now for sample (46)	4.5	2.8	1.6	10.3	2.1
Consumed salt, but no sample provided (54)	5.3	9.6	2.4	6.2	2.5
Salt sample provided and analyzed (778)	75.9	82.5	90.6	52.7	82.3
Salt sample provided, but lost in transit (57)	5.6	3.2	4.1	4.4	10.9
Households	1,026	251	245	292	238

Source: Analysis of data from the Papua New Guinea Household Survey on Food Systems, 2018.

Table 3: Household characteristics associated with survey household being in specific table salt sample category, multinomial logit regression analysis, relative risk ratios

	No packaged table salt consumed in past 7 days		Consumed salt, but no salt in household now for sample		Consumed salt, but no sample provided	
	Relative risk ratio	p-value	Relative risk ratio	p-value	Relative risk ratio	p-value
Female headed households, 0/1	1.381	0.420	1.273	0.626	2.936	0.006 ***
Household head age under 25 years, 0/1	1.483	0.567	2.110	0.322	0.762	0.744
Household head age 25 to 35 years, 0/1	1.284	0.439	0.672	0.348	0.374	0.021 **
Household head age 65 years or older, 0/1	0.791	0.680	2.156	0.133	1.507	0.401
Poorest consumption quintile, 0/1	2.174	0.053 *	1.039	0.938	1.982	0.171
2nd poorest consumption quintile, 0/1	1.033	0.937	1.249	0.627	1.440	0.485
2nd richest consumption quintile, 0/1	1.097	0.816	0.336	0.073 *	0.922	0.885
Richest consumption quintile, 0/1	1.262	0.589	1.028	0.954	2.700	0.046 **
Household size, number	1.007	0.918	0.926	0.387	0.986	0.858
No formal education for any HH member, 0/1	2.645	0.162	0.000	0.996	0.000	0.995
Secondary or tertiary highest educational attainment in HH, 0/1	0.392	0.001 ***	0.500	0.047 **	0.540	0.064 *
Non-farm activity head's primary occupation, 0/1	0.666	0.281	0.960	0.922	0.669	0.303
HH members engage in wage employment, 0/1	1.449	0.450	1.294	0.648	0.989	0.985
HH members engage in non-farm enterprise, 0/1	0.642	0.110	0.607	0.156	0.500	0.045 **
Household members include a current migrant (still considered part of household), 0/1	0.924	0.821	0.926	0.863	1.025	0.951
Household Dietary Diversity Score, foods consumed in past 24 hours out of 16 food groups	0.896	0.119	1.054	0.457	1.023	0.707
Worried about HH food insecurity past 4 weeks, 0/1	2.789	0.000 ***	1.569	0.178	0.602	0.117
Household with child under five years of age, 0/1	0.799	0.501	1.043	0.916	1.396	0.346
2 to 4 hours travel time to nearest town, 0/1	2.300	0.151	0.870	0.806	0.996	0.992
More than 4 hrs. travel time to nearest town, 0/1	18.853	0.000 ***	5.318	0.000 ***	2.151	0.025 **
Constant	0.027	0.000 ***	0.055	0.000 ***	0.070	0.000 ***
Observations	91		46		54	
Total observations: 1,026; Pseudo R-squared: 0.155						

Source: Analysis of data from the Papua New Guinea Household Survey on Food Systems, 2018.
Note: * = p < 0.10, ** = p < 0.05, *** = p < 0.01. HH = household.
Base table salt sample category: Households for which "Salt sample provided and analyzed". Base explanatory variable categories: Age of household head: household head age 36 to 64 years; Consumption-based welfare quintile: middle (third) quintile; Maximum educational attainment in household: primary education; and Travel time to nearest town: less than 2 hours.

exploring the characteristics of households that fall into each salt sample category, we may gain additional insight into household characteristics associated with table salt consumption of households in rural communities of PNG.

To examine the characteristics associated with each category of households, we used a multinomial logit regression analysis. The base category for this analysis is that of households in the "Salt sample provided and analyzed" category. In examining the results, the relative risk ratios (which can be interpreted in a similar manner to the odds-ratios of the logistic regression) indicate the odds that a household in the base category would fall into the corresponding category of households with a one-unit change in the explanatory variable.

The results of the multinomial logit are presented in Table 3.[3] As expected, the results for the first category of households, which did not consume packaged table salt in the previous seven days, are similar to those seen in the logistic regression results in Table 1. In the multinomial logit analysis here, neither primary education nor household dietary diversity is associated with membership in this group. However, as was seen in the logistic regression analysis, being in the poorest quintile of households and being worried about food insecurity recently are. We also see the strong association between membership in this group and

[3] Results are not presented in Table 3 for households in the "Salt sample provided, but lost in transit" category of household. This category of households was included in the analysis to determine whether these 57 households differed in any of their characteristics from the 778 survey households whose salt samples were analyzed. If differences were seen, some bias may have been introduced into the aggregated results based solely on households for which salt samples were analyzed. The results, which can be provided upon request, showed no strong difference in households characteristics between the two groups of survey households. Only one variable was shown to be significantly different between the two groups – households in the group whose samples were lost have higher dietary diversity.

Box 1: Traditionally produced salt

In the food consumption module of the household questionnaire, it was specified that the salt item of interest was "Packaged salt for table & kitchen". In many remote communities of PNG that are distant from towns and marketplaces, as our analysis shows, packaged salt is not readily available. In such communities, salt will be produced using traditional methods, including from washing the ash of plants that synthesize and accumulate salt as they grow or from springs that produce saline water, in both cases boiling the salt solution to concentrate the salt and then drying it. As such salt is not iodized, it falls outside of the interests of the analysis here.

In West Sepik, enumerators collected traditional salt samples from six survey households. Photos of some of the samples were taken. Unfortunately, all six samples were among those that were lost in transit to the laboratory in Port Moresby. Consequently, no information on their iodine content is available, although we would expect the content to be minimal.

residence in a community that is very remote from any town.

The remaining two categories for which results are presented in Table 3 are similar in that both reported consuming table salt in the past seven days, but no sample was obtained from them. However, in accounting for why no table salt sample was collected, the survey enumerator recorded different reasons – the first, although they consumed salt in the past week, now had no salt in their households, while the other category of households refused to give a sample. Why they were unwilling to do so was not recorded, but could have been due to the household having only a limited supply of salt and they could not spare any, or simply that the household did not want to provide any salt for analysis. Households in the first of these two categories almost certainly were constrained in their salt consumption. Some of the households in the second category may also have been constrained, but not necessarily so.

The results for these two categories differ. The principal factor of significance for households that had no salt to provide for a sample are that they are remote, similar to households that did not report consuming any salt.

In contrast, the pattern of significant factors associated with households that did not provide a sample suggest that the reasons for their not providing a sample are a mixture of both households with limited resources and other households being simply unwilling. Remote household were unlikely to provide a sample, as were female-headed households. However, also the wealthiest households in the sample are associated with being in this category, which suggests that the household was simply unwilling to provide a sample, despite having table salt in the household.

Examining salt consumption patterns based on whether the household provided a salt sample somewhat extends the earlier analysis based solely on reported salt consumption. The main finding of this extension to the analysis is simply further confirmation that remote house-holds are significantly more likely than households located closer to major towns to not have been in a position to provide a sample of the packaged table salt that they consume. For many, this is because they had none or little to spare. This again suggests that households in remote communities are less likely than other households in rural PNG to consume salt that has been fortified with iodine. Such households face a greater risk of experiencing the physical and mental development and health and cognitive challenges associated with iodine deficiency.

Iodine content in salt samples obtained from survey households

We now turn to the results of the iodine testing of the 778 table salt samples obtained from survey households that were then successfully analyzed in the Micronutrient Research Laboratory in Port Moresby. Table 4 summarizes the results for all of the samples jointly and disaggregated by the four study areas and by travel time to the nearest large town. The results generally are encouraging. Almost two-thirds of the salt samples fall within the expectations at household level of the PNG salt iodization regulations of the iodine content being between 30 and 50 ppm.

Table 4: Iodine content in table salt samples obtained from survey households

		Study area				Travel time to town		
	All	AR Bou-gainville	East Sepik	Madang	West Sepik	< 2 hrs	2-4 hrs	> 4 hrs
Iodine content, ppm								
Mean	41.4	41.4	43.4	45.4	35.8	40.5	39.8	44.1
Standard deviation	14.6	16.8	12.3	15.9	11.5	12.1	16.4	16.0
Median	39.1	37.1	41.6	41.0	35.4	39.6	35.8	40.1
Minimum	2.5	6.5	11.8	2.5	4.0	4.0	8.1	2.5
Maximum	116.4	116.4	108.7	95.8	82.3	84.3	116.4	95.8
Iodization standards for Papua New Guinea, % samples								
Inadequate, less than 30 ppm	16.4	23.7	6.8	10.5	24.5	12.3	25.6	14.3
Adequate, 30 to 50 ppm	**63.0**	**50.7**	**72.1**	**60.1**	**67.9**	**71.8**	**54.1**	**57.8**
Excessive, more than 50 ppm	20.6	25.6	21.2	29.4	7.6	15.8	20.3	27.8
Household provided a sample, % of all HHs	75.9	82.5	90.6	52.7	82.3	84.8	83.8	61.0
Households with sample, n	*778*	*207*	*222*	*153*	*196*	*341*	*207*	*230*
All survey households, n	*1,026*	*251*	*245*	*292*	*238*	*402*	*247*	*377*

Source: Analysis by the Micronutrient Research Laboratory, Port Moresby, of table salt samples obtained from survey households for the Papua New Guinea Household Survey on Food Systems, 2018. ppm = parts per million.

One-fifth of the samples have an iodine content above 50 ppm with an excessive level of the micronutrient. One-sixth of the samples were found to have iodine levels below 30 ppm, the lower end of the acceptable range under the PNG salt iodization regulations. Disaggregating the laboratory results by the four study areas or by distance to the nearest large town, as shown in Table 4, does not provide much insight into what might account for these table salt samples with iodine content outside of the acceptable range.

To better understand what might account for samples containing either inadequate or excessive levels of iodine, we again use a multinomial logit regression analysis at household level. The base category for this analysis is that of households who provided samples with an iodine content that are within the expectations at household level of the

Table 5: Household characteristics associated with survey household having provided a table salt sample with either inadequate or excessive levels of iodine, multinomial logit regression analysis, relative risk ratios

	Inadequate iodine, less than 30 ppm		Excessive iodine, more than 50 ppm	
	Relative risk ratio	p-value	Relative risk ratio	p-value
Female headed households, 0/1	1.437	0.315	1.360	0.363
Household head age under 25 years, 0/1	0.197	0.139	0.765	0.666
Household head age 25 to 35 years, 0/1	1.184	0.504	0.977	0.924
Household head age 65 years or older, 0/1	0.890	0.790	1.047	0.905
Poorest consumption quintile, 0/1	1.758	0.086 *	0.676	0.238
2nd poorest consumption quintile, 0/1	1.105	0.766	1.227	0.475
2nd richest consumption quintile, 0/1	0.792	0.486	0.831	0.524
Richest consumption quintile, 0/1	0.709	0.330	1.280	0.410
Household size, number	0.869	0.017 **	0.988	0.812
No formal education for any HH member, 0/1	3.047	0.261	0.000	0.985
Secondary or tertiary education highest educational attainment in household, 0/1	0.858	0.564	1.507	0.121
Non-farm activity head's primary occupation, 0/1	1.248	0.359	0.469	0.003 ***
HH members engage in wage employment, 0/1	0.536	0.155	1.053	0.870
HH members engage in non-farm enterprise, 0/1	1.296	0.243	1.025	0.904
Household members include a current migrant (still considered part of household), 0/1	1.002	0.995	1.221	0.412
Household Dietary Diversity Score, foods consumed in past 24 hrs out of 16 food groups	1.167	0.000 ***	0.986	0.729
Worried about HH food insecurity past 4 weeks, 0/1	1.039	0.864	0.710	0.094 *
Household with child under five years of age, 0/1	1.214	0.441	0.820	0.366
2 to 4 hours travel time to nearest town, 0/1	2.205	0.002 ***	1.726	0.029 **
More than 4 hrs. travel time to nearest town, 0/1	1.372	0.244	2.226	0.000 ***
Constant	0.144	0.000 ***	0.257	0.007 ***
Observations	128		160	
Total observations: 778; Pseudo R-squared: 0.067				

Source: Analysis of data from the Micronutrient Research Laboratory, Port Moresby, of table salt samples obtained from survey households for the Papua New Guinea Household Survey on Food Systems, 2018.
Note: * = p < 0.10, ** = p < 0.05, *** = p < 0.01. HH = household; ppm = parts per million.
Base table salt sample category: Households for which sample had "Adequate iodine, 30 to 50 ppm".
Base explanatory variable categories: Age of household head: household head age 36 to 64 years; Consumption-based welfare quintile: middle (third) quintile; Maximum educational attainment in household: primary education; and Travel time to nearest town: less than 2 hours.

PNG salt iodization regulations of between 30 and 50 ppm. The results are shown in Table 5.

Limited additional insights are gained from the multinomial logit regression analysis of iodine levels in the table salt samples obtained from survey households. Most of the explanatory variables with a significant relative risk ratio for one category do not show a consistent pattern with the results on that variable for the other category. For example, we find that table salt both with inadequate amounts of iodine and with excessive amounts is more likely to be consumed by households in more remote communities, particularly those that are located 2 to 4 hours from the nearest town. It is difficult to develop a plausible explanation for these and for other variables with significant results. We conclude that it is unlikely that any household characteristics are closely associated with whether the table salt the household consumes has either inadequate or excessive amounts of iodine.

A more important factor is likely the manufacturer of the iodized salt. The brand name of the salt was recorded for all of the samples obtained. Six table salt brands made up 94.5 percent of the 778 samples obtained, with one of the brands accounting for over half of all samples. The adequacy of the iodine content of the table salt samples by brand is presented in Table 6.

Table 6: Brands of table salt samples and iodine content, percent of samples

Table salt brand	Share, %	Row total, %			Principal study areas in which brand is found
		Inade-quate	Ade-quate	Excess-ive	
Brand 1	7.7	8.3	70.0	21.7	East Sepik; West Sepik
Brand 2	7.2	5.4	26.8	67.9	AR Bougainville
Brand 3	50.9	22.5	66.7	10.9	All, except Madang
Brand 4	6.9	9.3	66.7	24.1	All, except AR Bougainville
Brand 5	13.5	12.4	74.3	13.3	Madang
Brand 6	8.2	7.8	45.3	46.9	Madang
Other	5.5	18.6	60.5	20.9	Madang
	100.0	16.4	63.0	20.6	--

Source: Analysis of data from the Papua New Guinea Household Survey on Food Systems, 2018.
Note: Total samples: 778. Iodine content is evaluated using the PNG iodization standards: "Inadequate" is less than 30 parts per million (ppm); "Adequate" is 30 to 50 ppm, and "Excessive" is more than 50 ppm.

As different brands of table salt are found in different study areas, the iodine content of the particular brand of table salt may be an important factor in accounting for the different levels of adequacy in iodine content seen in each study area (see Table 4). The most common brand used by survey households in southern Bougainville generally contains excessive amounts of iodine. High levels of iodine are also seen in one of the common brands used in Madang. The most common brand used by all survey households, Brand 3, has the largest share of samples with inadequate amounts of iodine. These results suggest that continual monitoring of the iodine content of salt produced in PNG or imported into the country is required by the regulatory authorities to ensure that the salt meets the standards.

In terms of the significance of the varying iodine content in packaged table salt in PNG that is branded as being iodized, inadequate iodine is certainly a public health problem that requires attention. The incidence of iodine deficiency disorders will increase if significant amounts of packaged table salt with an inadequate amount of iodine are allowed to be sold across PNG.

However, better understanding the health significance of samples with iodine levels above the recommended range – table salt with excessive iodine – will require a more detailed understanding of iodized salt consumption by individuals than is possible to attain from the 2018 survey. Excessive consumption of iodine can result in hyperthyroidism. But, only two of the 778 table salt samples collected in the survey had iodine levels more than twice the recommended maximum level of 50 ppm. Given that table salt consumption levels generally are quite low in most areas of rural PNG, the current amounts of excessive iodine in iodized table salt would not seem to be a pressing public health concern, even if more investigation and continued monitoring of iodine levels in commercial table salt should be done.

DISCUSSION

There are two main policy implications that can be drawn from this research. First, although most do, there remain a sizeable number of Papua New Guineans who do not consume packaged table salt. These individuals, commonly living in very remote rural communities, are likely to be at significantly higher risk of the negative growth and health ramifications of iodine deficiency than the broader population of the country. The limited commercial networks in remote areas of PNG generally will not supply packaged table salt to households living in those areas. These communities will primarily rely on salt for their food that they produce themselves using traditional methods. Such salt, of course, is not iodized.

Figure 4: Goods on sale, including table salt in bags at left center, in village shop in southern AR Bougainville, 2017

Source: Authors.

For households living in remote communities, ensuring that they consume sufficient iodine will require more than requiring that all packaged table salt in PNG meet certain iodine content levels. Even though packaged table salt is among the handful of commercial products – alongside matches, soap, batteries, rice, sugar, tinned fish, and tinned meat – that may be found in rural shops (Figure 4), there remain many communities in which such shops are not present or in which many community members will have insufficient cash income to obtain goods from such shops, even if they are present in their community.

For these remote communities, continued efforts are needed to deepen their engagement with markets to ensure that all are utilizing iodized table salt. However, while salt iodization should be the long-term objective for addressing iodine deficiency in PNG, such an approach, as we have seen in the survey data analysis, is not yet able to reliably reach all citizens of the country. From a public health perspective, meeting the dietary iodine requirements of residents of remote communities will involve going beyond universal salt iodization. Specific public health outreach efforts to ensure that such individuals are consuming enough iodine will be needed. Technically, this will require the use of iodized oil, either as injections or orally, or alternative clinical approaches for iodine supplementation (Dunn and van der Haar 1990) that could be administered as part of public health campaigns, such as, for example, around vaccinations. Such efforts should particularly target women of childbearing age and young children. Only in this way can the iodine requirements for all those in PNG who have insufficient iodine in their diet be met and the significant physical and cognitive growth and development burdens caused by iodine deficiency be lifted across the country.

Second, for those Papua New Guineans who consume packaged table salt, universal salt iodization is an effective means to supply them with dietary iodine for the prevention of iodine deficiency disorders. The analysis of the iodine content of the table salt samples collected from the 2018 rural survey households showed that most samples met the PNG regulations for salt iodization. Only one out of six samples had iodine levels below the acceptable range.

However, when the samples were examined based on brand name, it was found that samples with inadequate amounts of iodine were most prevalent for the most commonly consumed brand of table salt. This suggests that closer monitoring of the iodine content in table salt produced or imported into PNG and enforcement of salt iodization regulations is required. Iodine losses from iodized salt can occur after production due to the manner in which the salt was iodized, deficiencies in packaging, and how the salt is stored (WHO 2014). Nonetheless, despite some likely post-production iodine losses, salt producers and importers need to be certain that the iodine levels in the salt they sell in PNG meets national standards before it is distributed to shops and markets across the country.

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ACKNOWLEDGMENTS

The Australian Department of Foreign Affairs and Trade (DFAT) provided funding for the survey implementation and analysis. World Vision-PNG played an important role in the survey fieldwork, supporting Tebbutt Research as their teams of enumerators implemented the survey. UNICEF-PNG provided technical and material support for the nutrition-related aspects of the survey. The support of the staff members involved with the survey at these various agencies is gratefully acknowledged. Thanks also to IFPRI colleagues Gracie Rosenbach and Rachel Gilbert for their work with and guidance on the use of the 2018 survey data set.

Funding for this work was provided by the Department of Foreign Affairs and Trade (DFAT) of the government of Australia and the CGIAR Research Program on Policies, Institutions and Markets (PIM). This publication has been prepared as an output of Papua New Guinea Survey on Food Systems Project and has not been independently peer reviewed. Any opinions expressed here belong to the author(s) and are not necessarily representative of or endorsed by IFPRI, DFAT, PIM, or CGIAR.

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The work of the International Food Policy Research Institute (IFPRI) in Papua New Guinea is financially supported by the Department of Foreign Affairs and Trade (DFAT) of the government of Australia. The research presented here was conducted as part of the CGIAR Research Program on Policies, Institutions, and Markets (PIM), which is led by IFPRI. This publication has not been independently peer reviewed. Any opinions expressed here belong to the author(s) and do not necessarily reflect those of IFPRI, DFAT, PIM, or CGIAR.