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Bridging the Knowledge Gap: Discerning the Association between Adequately Iodized Salt Coverage and Household Knowledge, Attitudes and Practices in Madagascar

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Abstract

Background: Iodine deficiency disorders are one of Madagascar's public health issues regarding the low level of iodine concentration in the population as assessed in 2015. Since then, the national salt iodization program has been revitalized. Therefore, this study aimed to estimate the coverage of households' adequately iodized salt in Madagascar and assess their level of Knowledge, Attitudes, and Practices regarding iodized salt use and associated factors. Materials and Methods: A cross-sectional population-based study using a multistage random sampling was conducted in 2020 in 4410 households in Madagascar. After informed consent, a pre-tested questionnaire on iodized salt was administered to the households, followed by a table, or cooking salt sample collected for iodine content testing using the iodometric titration technique. In addition, bivariate and multivariate analyses were conducted at 95% confidence level to identify associated factors. Results: The study results estimated the coverage of adequately iodized salt (15-60 ppm) nationwide at 41.1% (CI95%: 39.7%-42.2%) with significant differences between provinces. In addition, 36.8% of women had a "good" knowledge, 45.0% "good" practice of iodized salt, and 24.4% had a "positive" attitude towards iodized salt. Finally, the study identified the following associated factors to adequately iodized salt: attitude or perception towards iodized salt, household size, residence, economic status, and education level. Conclusion: Household coverage of adequately iodized salt has improved since 2015 but remains below WHO recommendations. Thus, the Ministry of Health and its partners could reinforce nutrition education efforts on household attitudes toward iodized salt and other associated factors to maintain coverage progress.

Keywords: *Coverage, iodine deficiency disorders, iodized salt, supplementation.*

Introduction

Iodine is a trace element found in some plants and seafood that is essential for proper thyroid function. In particular, in the synthesis of thyroid hormones, thyroxine (T4) and triiodothyronine (T3). These hormones are necessary for protein synthesis. They also promote nitrogen retention, glycogenolysis, intestinal absorption of glucose and galactose, and lipolysis and glucose absorption by adipocytes. Therefore, a deficiency of iodine in our diet leads to many health problems, including non-exhaustive risks of goiter development, impaired mental function, hypothyroidism, or increased sensitivity to nuclear radiation in the general population. In addition, pregnant women have risks of spontaneous abortion, stillbirths,

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congenital disabilities, and endemic cretinism [1].

The latest estimates on global iodine status show that nearly 88% of households used salt-containing some iodine in 2018-this means that almost 1 billion people did not consume iodine [2]. But iodine alone is not enough to prevent iodine deficiency disorders (IDD); it should be adequately iodized. In Madagascar, the urinary iodine concentration (UIC) was 46 µg L-1 (interquartile range-IQR:13-98 µgL-1) in 2014/15, indicating moderate iodine deficiency, and only 26.2% (95% CI 22.1-31.0) of households with women of reproductive age (15-49 years) used adequately iodized salt (≥15 mg kg-1) in 2015 [3].

An analysis of bottlenecks and solutions [4] followed this low level of coverage in order to improve the universal iodization program implemented in 2015 (by Decree No. 95-587 of 05/09/1995). Thus, the program was revitalized by the Ministry of Public Health with the private sector and small and medium salt producers to create an enabling environment and increase the supply of iodized salt in the country.

Five years later, this study is part of the process of monitoring progress on iodized salt coverage in the country, with the objectives of 1) determining the level of knowledge, attitude, and practice of iodized salt (iodized salt) at the household level, 2) determining the level of coverage of adequately iodized salt at the household level at the national and sub-national (provincial) level in 2020, and 3) determining the factors associated with the availability of adequately iodized salt at the household level.

Research Methodology

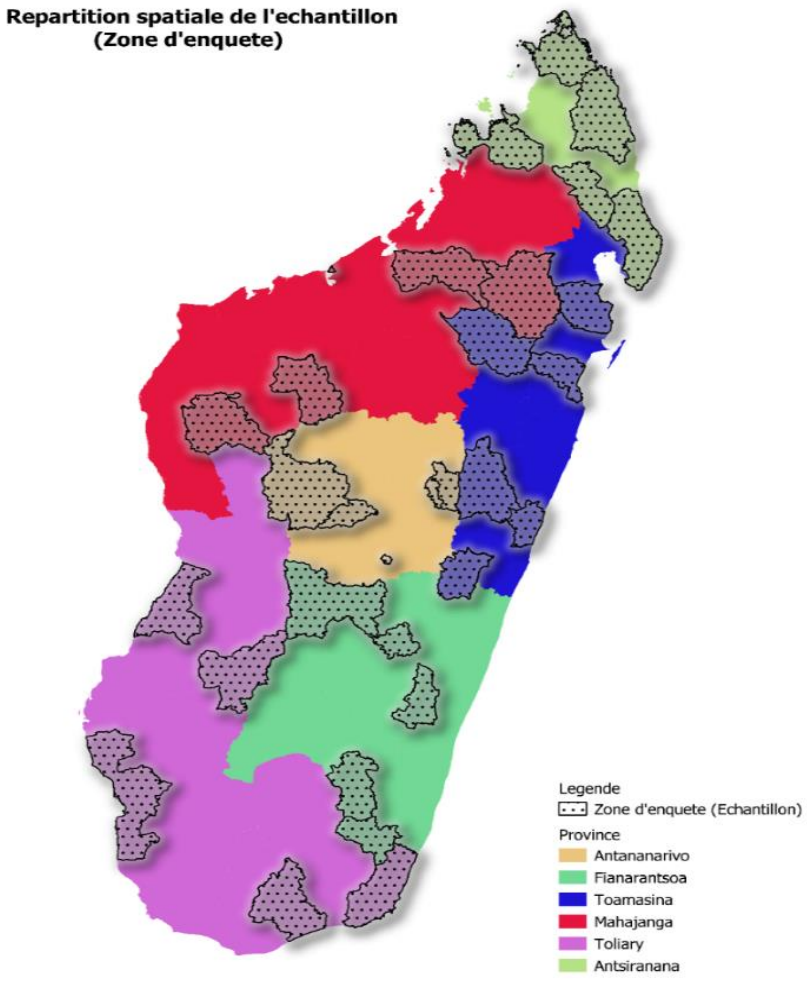

Figure 1:Spatial distribution of survey sample areas

Selection of Study Area

The study aimed to provide estimates at the national and sub-national levels, meaning representative of each of the country's six (6) provinces (Tananarive, Diego-Suarez, Fianarantsoa, Majunga, Tamatave, and Toliary).

Selection of Households

Inclusion criteria: All consented households were sampled for table or cooking salt collection for coverage of adequately iodized salt estimation and consent-given women responsible for purchasing and/or food cooking for iodized salt knowledge, attitudes, and practices (KAP) module.

Exclusion criteria: Households that did not consent to sample table salt collection OR women in households that did not agree to participate in the specific KAP module OR who were absent during enumerators' interview were excluded from the study.

Sample Size Determination

This cross-sectional study was one of the sub-studies of a national survey on micronutrient coverage and women's nutrition conducted in Madagascar in February 2020. The main objective of this national survey was to determine the coverage of the following micronutrients: vitamin A, iron and/or folic acid, deworming of children and women, and iodine at the household level. It covered 4410 households nationwide. This sample size ensured national-level representativeness in each of the country's six provinces, with 735 households per province (or approximately 36 villages with 20 households).

The following formula [5, 6] was used to estimate the minimum sample size (n) for a level for the complete survey.

$$n = \frac{z^2 \times r \times (1-r) \times deff}{e^2 \times pb \times AveSize \times RR}$$

With 95% confidence level z^2=1,96; expected proportion set to *r*=50% in order to maximize the sample size; survey design effect to account for the 3-stage survey *deff*=2,5; margin error related to survey precision *e*=7%; proportion of the target population (children under 5) *pb*=15,3% according to MICS 2018; the average household size AveSize=4,5; and expected response rate RR=97%.

Households were selected using a three-stage sampling method stratified by province. First, one to three districts per region were initially drawn proportionally to their size using the latest 2018 census data, meaning 31 districts in all six provinces. Then, the fokontanys (village name in the local language) were randomly selected with a probability proportional to size using the Ministry of Public Health database "Sectorisation-2019" and the latest 2018 census data adjusted to 2020 from the Madagascar National Institute of Statistics.

Finally, within the selected clusters (villages), capacitated enumerators on field sampling counted all the households. Then, they systematically selected 20 households by applying a sampling step determined with the total number of homes and a random seed assigned to each village.

Data Collection

A 10-day capacity building was organized for enumerators on data collection and questionnaire administration, including one day dedicated to sample household table salt collection and knowledge, attitudes, and practices module. Survey procedures and questionnaires were tested in two clusters (40 households) for tool validation before the main data collection held from February 1 to March 25, 2020, in the 223 country's level selected clusters.

Associated factors and exposure determination: The questionnaire on socio-demographic characteristics and household

assets was developed according to the DHS model. In addition, Salt and Iodine-related Knowledge, attitudes, and practices (KAP) were designed and assessed according to the FAO guide to nutrition-related-KAP surveys [7] and the work of Gerensea and al. [8] and Nabarun Karmakar and al. [9] done in Ethiopia and India, respectively, in 2015.

Socio-demographic variables: The independent variables were the profile of the head of household, including age, gender, education level, and household parameters including household size and wealth quintile. The wealth quintile was determined using household assets after a principal component analysis aligned with the DHS approach [10].

The measure of knowledge, attitude, and practice on iodized salt: A scoring system was set up with 1 point assigned to the correct answer and 0 otherwise within each of the three domains: knowledge, attitudes, and household' practices on iodized salt. Then, household knowledge and practices on iodized salt were classified as "good" if the household correctly answered to at least 50% correct answers and "poor" otherwise. Similarly, the classification was 'positive' if at least 50% of questions on attitude towards iodized salt were correctly answered and "Negative" otherwise.

Measuring adequately iodized salt: A 30-g sample of table salt was collected from each consenting household during data production. In addition, non-consenting households were asked about the other modules, including socio-demographic characteristics and their knowledge, attitudes, and practices towards iodized salt. Salt samples collected from households were coded with the cluster and household identifier and sent to the Nutrition Service (SNUT) Laboratory within the Madagascar Ministry of Public Health.

The iodine content of the samples was determined by the iodometry technique [11] by two technicians of the SNUT laboratory. Then, the average value of these two measurements was taken as the final value of iodine content. Household salt was considered adequately iodized if the ppm level was between 15 and 40 ppm as defined by WHO [1] and between 15 and 60 ppm according to national standards (Nutrition Service, Family Health Directorate, 1994), and inadequately iodized otherwise.

Statistical Analysis

Statistical analyses were performed using STATA version 14 software. First, univariate and bivariate statistics were used to assess respondent and household profiles and estimate the coverage of adequately iodized salt at the household level. a Person chi-square (χ^2) was used to evaluate the significance at p-value<=0.05. Then, multivariate analyses were conducted using binomial logistic regression to understand the associations between household profiles, their salt and iodine-related KAP, and household adequately iodized salt access. Thus, the three KAP dimensions were considered as explanatory variables, in addition to the variables with a p-value<0.2 of household profile (size, socioeconomic status, area of residence) and women (age group). Odds ratios (OR) were calculated to assess the association strength between independent variables and the outcome at 95% Confidence Interval (CI). All proportion estimates, confidence intervals, and regressions were adjusted with sample weight to account for study design considering household' unequal probabilities to be selected.

Ethical Considerations

This sub-study component of the national survey on "Vitamin A Coverage and Woman Nutrition-ENVNUT", conducted to monitor the transition project of micronutrients, especially vitamins and deworming in the routine health system, received full authorization from the Ministry of Public Health of Madagascar in June 2018 (ref: 066/MSANP/CERBM-2018) and the National Ethics Committee on Biomedical Research before implementation. Households also received an introductory informed consent session from the investigators regarding their

voluntary participation. They gave their informed consent before all interviews and table sample collection in the household.

Results and Discussions

Of the 4,410 households expected to participate in the survey, 4,325 were interviewed (98% response rate). The median household size was 4 persons (interquartile range-IIQ: 3-5), and 75.7% lived in rural areas with income sources mainly from agriculture and related activities (71%), and handicrafts (13%). In 22.5% of cases, these households were headed by women, who were the head of the household.

Knowledge, Attitudes, and Practices on Iodized Salt

Knowledge: (as shown in table 1) The majority of the 3,587 women, who agreed to participate in the face-to-face interview about the iodized salt module, were aware of iodized salt (51.8%). However, 83.2% mentioned that it was regular salt with a small amount of iodine included. On the other hand, only 39.1% of the women reported that iodized salt is important for health, 11.6% confirmed that it was not, and almost half of the respondents did not know (49%). Among those who reported the importance of iodized salt for health, more than 9 out of 10 women gave more details such as iodized salt helps to stay healthy (70.1%), prevent goiter (14.5%), or prevent any other iodine deficiency (4.7%). Also, only 20.8% of the women surveyed rightly reported that there was no difference in taste between iodized salt and regular salt.

Overall, for all questions related to knowledge of iodized salt, only 1224 women-36.8% (95% CI 34.9-38.9) had "good" knowledge of iodized salt nationwide. There was a statistically significant difference (p-value=0.0000) in the proportion of households with "good" knowledge of iodized salt and the province to which the household belonged (Chi2=49 p-value=0.000). Indeed, the province of Antananarivo has the highest proportion (65.1%) of households with "good" knowledge about iodized salt, followed by the province of Fianarantsoa (47.3%). The other four (4) provinces have knowledge levels below the national estimate (36.8%), with Antsiranana province having the lowest level of knowledge about iodized salt (22.3%).

Table 1. Household Knowledge of Iodized Salt

Questions	**Items**	**Frequency (out of 3587)**	**% ****
Summary: Household knowledge of iodized salt	1.Good	1214	36,8%
	2.Poor	2373	63,2%
Have you heard of iodine salt?	1.Yes	1778	51,8%
	2. No	1447	37,8%
	88. Don't know	362	10,4%
If you have heard of iodine salt, what is it?	1.Ordinary salt with a small amount of iodine	1434	83,2%
	2. Ordinary salt, rock salt (Siratany)	171	8,1%
	99. No response	173	8,8%
Does the salt you use for cooking contain iodine?	1.Yes	865	27,3%
	2.No	1208	36,0%
	88. Don't know	1514	36,8%
	1.Yes	744	26,0%
	2. No	717	20,8%

Is there a difference in taste between iodized salt and regular salt?	88. Don't know	2126	53,1%
How do you recognize iodine salt?	1.SIR logo printed on the package	499	15,3%
	2. Iodine salt on the bag/box	1124	31,6%
	3. colour and design of the package	189	5,9%
	88. Don't know	1449	39,5%
	99. No response	326	7,7%
Is the consumption of iodine salt important for health?	Yes	1330	39,4%
	No	418	11,6%
	88. Don't know	1839	49,0%
If so, why is it important for health?	To prevent goiter (swelling of the neck)	238	14,9%
	To stay healthy	834	70,1%
	To prevent iodine deficiency	48	2,9%
	To grow up well	116	6,8%
	88. Don't know	72	4,7%
	99. No response	22	0,6%
When there is an iodine deficiency in the body, that is, when there is:	Generalized weakness of the body	525	15,5%
	goiter	310	9,6%
	growth retardation	188	4,8%
	Brain development is impaired in children	44	1,4%
	Congenital malformation	5	0,2%
	Defects in hearing and speech	20	0,5%
	88. Don't know	2110	59,2%
	99. No response	385	8,7%

Attitudes: (as shown in Table 2) Attitudes are emotional, motivational, perceptual, and cognitive beliefs that positively or negatively influence an individual's behaviour or practice. This study showed that 73.7% of women preferred unpackaged salt (coarse salt), non-iodized. This preference was attributed mainly to habit, especially tradition (34.5%), to the relatively lower price of unpackaged salt (28.4%), and its quantity (28.8%). Health and salt quality were cited as reasons for preferring packaged or unpackaged salt were mentioned by only 12.1% and 6.7% of women, respectively. The importance of iodized salt in the diet was recognized by only half of the respondents, who said it was very important (18.9%) or somewhat important (32.2%).

Overall, good attitudes towards iodized salt are not common among respondents. Only 24.4% (95% CI 22.7-26.3%) of women have an attitude towards iodized salt that can be considered “positive”. This observation at the national level also shows significant differences according to the household origin, with Antananarivo province still having the highest proportion of households with a positive attitude (54.1%) and Antsiranana the lowest (8.1%).

Practices: (as shown in Table 2) The practice of iodized salt refers to behaviors, long-term or commonly practiced use, and observable trends toward greater access and effective use of

iodized salt in the household diet. This study showed that only 26.3% of women used packaged salt, 91% bought salt in local grocery stores in the fokontany (village), and nearly 47.9% used it in the middle of cooking. Nevertheless, on iodine storage, more than two-thirds of them store iodized salt in dry places (85.3%) and with a container with a lid (66.4%).

Overall, 45.0% (CI95% 42.9-47.1%) of women had "good" practice of consuming iodized salt according to all responses on the practice, the storage and cooking aspects that preserve the iodine content, as well as places of purchase. The consumption practices of iodized salt differ statistically across geographical areas. Thus, the province of Fianarantsoa has the highest proportion of women with 'good" practice of iodized salt (57.3%), followed by the province of Antananarivo (53.1%) and end with the province of Antsiranana (28.6%).

The province of Antsiranana has the lowest proportion of households on the three components of iodized salt: knowledge, Attitude, and Practice (KAP).

Table 2. Attitude and Practice on Iodized Salt Consumption

Questions	**Items**	**Frequency (out of 3587)**	**%**
Attitude to iodized salt consumption	**Positive**	**679**	**24,4%**
	Negative	**2908**	**75,6%**
What is your preference on Salt?	1. Packaged salt	744	26,3%
	2. Unpackaged salt (coarse salt)	2843	73,7%
Why do you prefer salt?	1. Taste	144	3,3%
	2. Tradition	1235	34,5%
	3. Quantity	623	14,8%
	4. Health	278	12,1%
	5. Salt quality	224	6,7%
	6. Free	13	0,4%
	7. Less Expensive	1070	28,4%
How important is iodized salt in your diet?	1. Very important	625	18,9%
	2. Somewhat important	1134	32,2%
	3. Not important at all	743	18,7%
	99. No response	1085	30,3%
Household practice of iodized salt consumption	**Good**	**1550**	**45,0%**
	Poor	**2037**	**55,0%**
What type of salt do you use?	1. Packaged salt	744	26,3%
	2. Salt purchased by Kapoka (Unwrapped)	2843	73,7%
Where do you store the salt?	1. Wetland	298	7,6%
	2. Dry Zone	3086	85,3%
	3. Pres of fire	203	7,1%
What type of container holds the salt in your household?	1. With cover	2422	66,4%
	2. Without cover	1165	33,6%
When do you add salt during cooking?	1. Start	1777	49,1%
	2. Environment	1700	47,9%

	3. At the end of the cooking process	110	3,0%
Where do you usually buy salt?	1. Local grocery store in the same Fokontany/ (same town)	2406	65,5%
	2. Grocery store/shop in the neighbouring fokontany or village	525	15,5%
	3. Wholesale store	23	1,0%
	4. At the weekly market	633	18,0%

Households with adequately iodized salt for consumption: (as shown in Table 3) During this study, 65.7% of households provided coarse salt, 33.6% fine salt, and 0.7% rock salt. The results of the analyses revealed that 28.2% (CI95% 26.8%-29.6%) of the households used adequately iodized salt according to the WHO definition (iodine content between 15-40 ppm) and 41.1% (CI95% 39.7-42.2%) according to the national micronutrient deficiency standards (iodine content between 15-60 ppm). We will refer to coverage according to the national standard in the following multivariate analyses of associations and this paper. Thus, the bivariate analyses showed significant disparities in the distribution of this coverage across the provinces. Indeed, Antsiranana province had the highest proportion of households with adequately iodized salt at 76.2% (95% CI 72.0-80.0%). Also, urban households had more access to adequately iodized salt than rural households, respectively 51.3% versus 37.9%, p=0.000, chi2. Furthermore, these results showed a positive and statistically significant association between household coverage of adequately iodized salt and good knowledge or attitude towards iodized salt.

In fact, 46.7% (CI95% 44.0-49.4%, p-value=0.000) of households had adequately iodized salt among those with good knowledge versus; 39.3% (CI95% 37.3%-47.3%) among those with “poor” knowledge (p=0.000, chi2) of iodized salt. The same was true for households with a positive attitude towards iodized salt; 53.9% (CI95%: 49.3%-58.2%, p-value=0.000) used adequately iodized salt compared to 38.2% (CI95%: 36.1%-40.3%) among those with a negative attitude towards iodized salt

The results also showed a significant and positive association between household socioeconomic well-being and access to adequately iodized salt. Indeed, the proportion of households with adequately iodized salt increased overall from the poorest multidimensional quintile (from 24.3%) to the wealthiest quintile (to 52.8%) (p-value: 0.00).

Table 3. Coverage of Households with Adequately Iodized Salt, by their Household Knowledge, Attitudes and Practices, by National & WHO Thresholds

		Households with an iodine content					
		Adequate (15-40 ppm)-WHO			**Adequate (15-60 ppm)-National**		
		Frecency NPs	**IC95%****	**sign**	**Frecency NPs**	**IC95%****	**sign**
National		**1505**	**28,2 [26,8 - 29,6]**		**2013**	**41,1 [39,7 - 42,6]**	
Province	Antananarivo	114	22,9 [20,1 - 25,8]	,000*	218	45,8 [42,5 - 49,2]	,000*
	Antsiranana	388	41,3 [36,6 - 45,9]		605	76,2 [72 - 80]	
	Fianarantsoa	247	25 [21,4 - 28,8]		296	29,1 [25,2 - 33]	
	Mahajanga	207	28 [24,9 - 31,4]		276	39,5 [36,1 - 43,1]	
	Toamasina	390	47 [43,7 - 50,4]		444	57,4 [54,1 - 60,7]	
	Toliary	159	9,7 [7,8 - 11,8]		174	11 [9,1 - 13,3]	
Residence	Rural	1247	27,7 [26,2 - 29,3]	,212	1611	37,9 [36,2 - 39,6]	,000*
	Urban	258	29,7 [27 - 32,6]		402	51,3 [48,2 - 54,3]	
Household knowledge of iodized salt	Good	416	28,9 [26,5 - 31,5]	,934	587	46,7 [44 - 49,4]	,000*
	Poor	844	28,8 [27 - 30,7]		1101	39,3 [37,3 - 41,3]	
Attitude to iodized salt consumption	Positive	237	32,4 [29,4 - 35,6]	,008*	369	53,9 [50,6 - 57,2]	,000*
	Negative	1023	27,7 [26 - 29,4]		1319	38,2 [36,3 - 40]	
Household practice of iodized salt consumption	Good	545	29,7 [27,5 - 32]	,297	725	43,8 [41,4 - 46,3]	,053
	Poor	715	28,2 [26,2 - 30,2]		963	40,6 [38,4 - 42,8]	
Household Wel-being index	The poorest	234	19,6 [17 - 22,3]	,000*	271	24,3 [21,5 - 27,3]	,000*
	Second	288	28,3 [25,3 - 31,4]		382	40,2 [36,9 - 43,5]	
	Medium	275	24,4 [21,6 - 27,4]		364	35,6 [32,3 - 38,8]	
	Fourth	327	33,1 [30 - 36,4]		468	53 [49,6 - 56,4]	
	The richest	381	35,6 [32,4 - 38,8]		528	52,8 [49,4 - 56,1]	

Factors associated with household coverage of adequately iodized salt: (as shown in Table 4) The results of the multivariate analysis, particularly the adjusted odds ratios for confounders, indicated the persistence of the effect of attitude on household coverage of adequately iodized salt. Indeed, a negative attitude toward iodized salt reduced the household's odds of having adequately iodized salt by 32% (AOR=0.68; CI95% 0.51-0.91). On the other hand, knowledge and practice were not associated with household coverage of adequately iodized salt. The other characteristics significantly associated with household coverage with adequately iodized were the education level of the women responsible for cooking in the household. In fact, women with secondary or higher education were 2.26 times (AOR:2.26; CI95% 1.62-3.17) and 2.11 times (OR: 2.11; CI95%:1.34-3.31) more likely to live in a household with adequately iodized salt, respectively, than those who were illiterate (or had no formal education). Also, larger households, i.e., more than the national median (4 persons), were 25% less likely to have adequately iodized salt.

Table 4. Regression Analysis Results

	Proportion	**Bivariate Analysis**	**Multivariate Analysis**
	% [IC95%]**	COR [IC95%]**	AOR [95% CI]**
All households (n=4325)			
Place of residence			
Urban	24.3 [22.8-26.0]	1 (ref)	1 (ref)
Rural	75.7 [74.0-77.3]	0,6 [0,5-0,72]*	0,63 [0,49-0,8]*
Province			
Antananarivo	19.5 [18.8-20.2]	1 (ref)	1 (ref)
Fianarantsoa	12.2 [11.5-13.0]	0,49 [0,37-0,63]*	0,7 [0,51-0,97]*
Toamasina	20.8 [19.8-21.8]	1,6 [1,23-2,08]*	2,55 [1,86-3,51]*
Mahajanga	17.4 [16.6-18.4]	0,77 [0,59-1,01]	1,19 [0,88-1,62]
Toliary	20.0 [19.0-21.0]	0,15 [0,11-0,19]*	0,26 [0,19-0,36]*
Antsiranana	10.2 [9.5-10.9]	3,79 [2,82-5,11]*	5,39 [3,81-7,62]*
Household size* (%)**			
<= 4 persons	47.4 [45.5-49.3]	1 (ref)	1 (ref)
More than 4 persons	52.6 [50.7-54.5]	0,86 [0,73-1]	0,75 [0,62-0,92]*
Wealth Index (quintile)			
Poorer	20	1 (ref)	1 (ref)
Second	20	2,09 [1,62-2,7]*	1,5 [1,1-2,04]*
Medium	20	1,72 [1,33-2,23]*	1,26 [0,92-1,71]
Fourth	20	3,52 [2,73-4,53]*	1,93 [1,41-2,63]*
The richest	20	3,48 [2,71-4,47]*	1,66 [1,2-2,28]*
KAP module (n=3587)-woman: household's food caterer			
Age of respondent			
15-29	61,2 [59,2-63,2]	1 (ref)	1 (ref)
30-49	38,8 [36,8-40,1]	1,4 [1,18-1,67]*	1,49 [1,22-1,81]
Respondent's level of education			
None/listed	12,6 [11,2-14,2]	1 (ref)	1 (ref)
Primary	46,4 [44,3-48,5]	2,57 [1,93-3,42]*	1,84 [1,35-2,51]*

College	31,7 [29,8-33,7]	4,16 [3,09-5,6]*	2,26 [1,62-3,17]*
High school and up	9,3 [8,1-10,6]	4,4 [2,99-6,47]*	2,11 [1,34-3,31]*
Knowledge of iodized salt			
Positive	36,8 [34,8-38,9]	1 (ref)	1 (ref)
Negative	63,2 [61,1-65,1]	0,74 [0,62-0,88]*	0,93 [0,72-1,18]
Attitude towards iodized salt			
Positive	24,4 [22,7-26,3]	1 (ref)	1 (ref)
Negative	75,6 [73,7-77,4]	0,53 [0,43-0,65]*	0,68 [0,51-0,91]*
Practice of iodized salt			
Good	45,0 [42,9-47,1]	1 (ref)	1 (ref)
Poor	55,0 [52,9-57,1]	0,88 [0,74-1,04]	1,09 [0,89-1,32]
*Results significant at the 0.05 level, OR= Odd ratio **Confidence intervals were determined by considering the design of the study, including the unequal probabilities of households with survey weights. NP: Not weighted; AOR= Adjusted Odd ratio; COR= Crude Odd ratio			

These results also confirm an association between the province of residence and household coverage of adequately iodized salt. Households in Antsiranana province had 5.4 (AOR: 5.39; 95% CI: 3.81-7.62) times more likely to have adequately iodized salt than those living in Antananarivo province. Households in Toliary province were 74% less likely to have adequately iodized salt than households originating from Antananarivo (reference) (AOR: 0.26 CI95% 0.19-0.36). The results of the multivariate analysis also confirmed the positive association between household socioeconomic status and the availability of adequately iodized salt. Those with a wealthier socioeconomic status than the first quintile was over 50% more likely to have adequately iodized salt.

Discussion

This study estimated that 36.8% (CI95%: 34.9%-38.9%) of women had a "good" knowledge of iodized salt, that only 24.4% (CI95%: 22.7%-26.3%) had a "positive" attitude toward iodized salt and that 45.0% (CI95%: 42.9%-47.1%) had "good" practices regarding iodized salt. The results also showed that 41.1% (CI95% 39.7%-42.2%) of households were covered with salt adequately iodized according to National standards, and 28.2% (CI95% 26.8%-29.6%) according to WHO standards [1]. This result is similar to a meta-analysis of 28 studies conducted between 2013 and 2020 in Ethiopia [12], from which it was found a combined coverage of 37% (95% CI: 28%-46%) as a proportion of households with adequately iodized salt (>=15 ppm). However, it was lower than the results of other studies conducted in South Africa and India, where coverage was 62.4% [13] and 75% [14], respectively. These differences could be explained by the economic status of the households, which we found to be associated with the coverage or the conditions of production of adequately iodized salt in the country.

The previous ENSIM survey [3] estimated that only 26.2% (CI95%: 22.1%-31.0%) of households with women aged 15-49 years who had adequately iodized salt (>15 ppm) in 2014, the present study estimated 44.7% (CI95%: 42.8%-46.6%) if used same criteria for comparison purposes. This significant increase of 18.5 percentage points in five years may reflect a positive iodized salt environment in the country following the revitalization of the national salt iodization program undertaken in 2015/2016. However, despite the progress, the national household coverage with adequately iodized salt of 41.1% remains far from the WHO recommendation (>=90%).

In addition to coverage, the results indicated an association of the two components of the KAP: attitude and practice of iodized salt in bivariate analysis. However, in the multivariate analysis, after adjusting for confounding factors, only attitude towards iodized salt was statistically associated with adequately iodized salt, in addition to household wealth, women's education, area of residence, and province of residence.

These results are also similar to studies in Bangladesh [15], which showed a significant association between attitude, practice, and adequately iodized salt in multivariate analysis (AOR=2.838, CI: 1.700-4.735); and in a meta-analysis of 31-sub-Saharan African countries, conducted between 2010 and 2018 [16], of which education level and well-being index were significantly associated with iodized salt, although the latter only considered iodized salt regardless iodine concentration.

Strenghts and limitations of the study: This study had many advantages, which can be summarized as follows: 1) it was the first to assess the level of knowledge, attitudes, and household practices regarding iodized salt in Madagascar and their potential association with household coverage of adequately iodized salt. 2) it provided estimates for all households at both the national and subnational (provincial) levels, thus filling the representativeness gap of the previous estimate, which was conducted in 2014 only for households with women aged 15-49 years [3], 3) it used iodometric titration - the gold standard for measuring iodine content - as part of the exposure measurement instead of the rapid test kits commonly used in national surveys such as the Demographics and Health Surveys (DHS), 4) it estimated the coverage of adequately iodized salt according to the national standard (iodine content 15-60ppm) and according to the WHO recommendation (iodine content 15-40 ppm) for cross-country comparisons.

The study was not without its limitations: first, a household adequately supplied with iodized salt does not necessarily mean that each member of that household is covered. Thus, the study did not assess the iodine status of school-aged children or women of childbearing age as part of national surveys to determine population iodine status. In addition, the cross-sectional nature of this study did not allow causal relationships to be established with iodine-sufficient salt at the household level.

However, this study provides a basis for further research, monitoring, and adaptation of the salt iodization program in Madagascar.

Conclusion

The objective of this study was to assess the national and sub-national (provincial) coverage of iodized salt in Madagascar and to determine household knowledge, attitudes, and practices (KAP) of iodized salt and potential associations between KAP and coverage. In conclusion, less than half of the women interviewed in households had “good” knowledge, “positive” attitude, or “good” practice of iodized salt. Thus, the proportion of households with adequately iodized salt in Madagascar remains low regardless of the threshold used-WHO standards (15-40 ppm) at 28.2% or national standard (15-60 ppm) at 41.1% compared to the WHO recommendation (>=90%). Multivariate analyses identified attitude/perception towards iodized salt, household size, place of residence or province of origin, socioeconomic status, and education level as factors statistically associated with household coverage of adequately iodized salt that could be addressed by policy interventions.

Conflict of Interest

All authors declare no conflict of interest.

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