Catumbela *et al.*
Journal of Health, Population and Nutrition (2025) 44:165
https://doi.org/10.1186/s41043-025-00907-1

Journal of Health, Population and Nutrition

RESEARCH

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Household iodized salt consumption and iodine status in women of reproductive age in Angola: a cross-sectional study

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Abstract

Background The first evaluation of iodine nutritional status in Angola was carried out in 2006. This involved a limited survey of urinary iodine concentration (UIC) among school-aged children, conducted in 24 schools within the municipalities of Bié Province. Almost all the children had moderate to high levels of iodine deficiency, with a median UIC below 100 µg/L. In 2004, the Iodine Global Network ranked Angola among the world's ten countries with the highest prevalence of iodine deficiency. This study aims to assess the household level of iodized salt and iodine status in women of reproductive age in Angola.

Methods In 2019, we conducted an observational, descriptive, prospective, cross-sectional study, stratified by altitude, using data from the 2014 Census. A multi-stage, proportional stratified sample selected 2250 households across the country, with 450 per province (Luanda, Cuanza Sul, Bie, Cunene, and Moxico). Descriptive statistics (means, medians, frequencies) were used to characterize the variables. Chi-squared and Kruskal–Wallis tests were employed to assess differences in iodine concentration between strata.

Results Overall, the findings indicated that 74.3% of households used salt containing some iodine, but only 29.2% used salt with adequate iodization (15–40 ppm). The median UIC was 102.2 µg/L in pregnant women and 108.2 µg/L in non-pregnant women. No statistically significant difference was observed between these two groups ($p = 0.48$).

Conclusions Key findings of the survey showed that the majority of the population in this study is consuming iodized salt below the range recommended by the World Health Organization. This result highlights the need to review the current iodine deficiency disorder control program and develop a country action plan to ensure that over 90 percent of households sustainably use adequately iodized salt and all women of reproductive age have adequate iodine intake.

Keywords Iodine, Iodized salt, Women, Urine, Diet, Sub-Saharan Africa, Angola

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Introduction

Iodine deficiency disorders (IDD) are a significant public health issue, affecting approximately two billion people globally. They are the primary cause of preventable developmental deficits in the central nervous system and impaired cognitive function in children, as well as the development of goiter and hypothyroidism in adults. While salt iodization is the preferred method for preventing and controlling IDD, in cases where salt is not a main food ingredient, other foods can be used for iodine fortification [1, 2].

Despite increased iodization of household salt reducing iodine deficiency globally over the past two decades, an estimated 1.8 billion people were still at risk of iodine deficiency in 2011. These estimates are based on the proportion of school-aged children with low urinary iodine concentration [2].

The progress of national Universal Salt Iodization (USI) strategies is typically evaluated by assessing household coverage of adequately iodized salt and median urinary iodine concentration (UIC) in spot urine collections [3].

A mini-survey conducted in 2006 on 24 schools in the province of Bie revealed that almost all children had moderate to high levels of iodine deficiency (UIC < 100 μg/L). Angola was ranked among the top ten countries with the highest prevalence of Iodine Deficiency Disorders (IDD) in school-age children, with 520,000 children at risk, by the Global Iodine Network (IGN) [4].

In 2014, the 2015–2016 Multiple Health Indicators Survey (MHIS) showed that rapid testing indicated nine out of ten households used salt containing some iodine. Over the past decade, the National Salt Iodization Program has made significant progress by establishing legislative and regulatory standards and conducting information, education, and communication activities on IDD at the community level. To increase the coverage of iodized salt, particularly adequately iodized salt, updated evidence on the iodine status in the Angolan population is necessary [5].

Angolan diets vary regionally, though they share common foundations. Funge, made from cassava or maize flour, is a staple, typically accompanied by fish, meat, or beans. In coastal areas, fish and seafood are abundant. Inland, game meat and local agricultural produce are prevalent. Palm oil is an essential ingredient. Fruits such as mangoes, bananas, and mucua are popular. Food availability and cost heavily influence dietary habits, with variations between urban and rural areas [6, 7].

Existing data on household coverage with adequately iodized salt and quantitatively measured iodine nutritional status in Angola are insufficient. The results of this study will provide valuable information for decision-makers to prioritize and invest in interventions for IDD, guide planning, monitoring, and evaluation, and address current constraints and gaps. Therefore, this study aims to assess the household level of iodized salt and iodine status in women of reproductive age (WRA) in five selected provinces of Angola from different ecological zones.

Materials and methods

Study design and participants

A household-based survey was conducted from July to September 2019, using a non-proportional stratified random sample from the country in three stages. For logistical and geographic accessibility reasons, the country was first divided into three ecological zones (Coastal, Central, and Eastern), with 2:2:1 provinces (total five provinces) randomly selected in each zone. Each province was then divided into urban and rural strata. In the five selected provinces, 18 census sections (National Institute of Statistics, 2014) were randomly chosen in each province, totalling 450 households (25 households per census section) and resulting in a sample size of 2250 families visited (Table 1).

Household sampling

The 2014 Angola General Population and Housing Census database was used, from which 25 households were

Table 1 Sample by Clusters per Province, by Area of Residence, Rural or Urban—IODINE, 2019

Province	Total		Urban		Rural	
	Census Sections	Households	Census Sections	Households	Census Sections	Households
Total	**90**	**2250**	**42**	**1050**	**48**	**1200**
Luanda	18	450	16	400	2	50
Cuanza Sul	18	450	6	150	12	300
Bié	18	450	7	175	11	275
Moxico	18	450	8	200	10	250
Cunene	18	450	5	125	13	325

systematically selected with equal probability within each cluster of the existing list. This selection was carried out using the following steps:

- The list of households for the selected cluster was checked and it was found that each household had a consecutive serial number.
- To obtain the selection interval for selecting households in the cluster (Ihij), the total number of households listed within the cluster (M'hij) was divided by the number of households to be selected (mhij).
- Ihij = M'hij/mhij
- A random number (Ahij) was chosen between 0 and Ihij. The selected households were identified by the following selection numbers:
- Shijk = Ahij + (k − 1) * Ihij, rounding up, where k = 1, 2, …, mhij
- The k-th selected household is the one with a serial number equal to Shijk.

On the other hand, for the estimates of each survey to be representative of the population, it was necessary to multiply the data by a weighting factor. The basic weight for each selected household was equal to the inverse of its selection probability, which was calculated by multiplying the probabilities for each sampling stage. Given the two sampling stages, the selection probability was calculated using the following formula:

- phij = (nh/Mh) * (mhij/M'hij)
- where:
- phij = selection probability for households selected in the j-th cluster of the i-th primary sampling unit of the base in stratum h
- nh = number of clusters selected in stratum h for the survey
- Mh = total number of family dwellings (accumulated total of size measures) in the 2014 RGPH base for stratum h
- Mhij = total number of households in the 2014 RPGH base for the j-th cluster of the i-th primary sampling unit of stratum h
- mhij = number of households selected for the survey in the j-th cluster of the i-th primary sampling unit of stratum h
- M'hij = total number of households listed in the j-th cluster of the i-th primary sampling unit of stratum h

The basic weight, or expansion factor, was calculated as the inverse of this selection probability. Based on the selection probability specified above, the basic weight was calculated using the following formula:

- Whij = 1/phij = (Mh/nh) * (M'hij/mhij)
- where:
- Whij = basic weight for households selected in the j-th cluster of the i-th primary sampling unit of stratum h

Given that the weights are calculated at the cluster level, the weights were adjusted at this level. The final weight (W'hij) for households in a survey sample can be expressed as follows:

- W'hij = Whij * (m'hij/m"hij)
- where:
- m'hij = number of valid households selected in the j-th cluster of the i-th primary sampling unit in stratum h (excluding destroyed or uninhabited houses)
- m"hij = number of households with completed interviews in the j-th cluster of the i-th primary sampling unit in stratum h.

The estimate of a total can be expressed as follows:

- $\hat{Y}$ = Σh Σi Σj Σk W'hijk * yhijk
- where:
- L = number of strata
- yhijk = value of variable y for the k-th household within the j-th cluster in the i-th sample primary sampling unit in stratum h

This total is simply the sum of the weighted data for all households in the sample for the corresponding strata.

The estimate of a ratio was calculated as follows:

- $\hat{R} = \hat{Y}/\hat{X}$
- where $\hat{Y}$ and $\hat{X}$ are estimates of totals for variables y and x, respectively, calculated as specified before.

In the case of a stratified multi-stage sample, such as Mother Sample-based surveys, means and proportions are types of ratios. In the case of a mean, variable x in the denominator of the ratio would be equal to one for each unit of analysis (e.g., household), so the denominator would simply be the sum of the weighting factors. In the case of a proportion, variable x would also be equal to one for all units, and variable y would be equal to one or zero, depending on whether the unit has the characteristic of interest.

The standard error, or square root of the variance, is used to measure the sampling error, but can also include the variable part of non-sampling errors. The variance estimator must take into account the different aspects of the sampling design, such as stratification and clustering. SPSS (Complex Samples) and Stata programs use a variance estimator that takes into account the sampling plan. These programs use a variance estimator called"ultimate clusters."For the estimate of a total, the variance is calculated by SPSS and Stata using the following formula:

Variance Estimator for a Total.

- $\mathrm{Var}(\hat{Y}) = \Sigma h\ [nh/(nh-1)] * \Sigma i\ (\hat{Y}hi - \hat{Y}\bar{h}).^2$
- where:
- $\hat{Y}hi = \Sigma j\ \Sigma k\ W'hijk * yhijk$
- $\hat{Y}\bar{h} = (1/nh) * \Sigma i\ \hat{Y}hi$

For the estimate of a ratio, SPSS and Stata using the following formula calculate the variance:

Variance Estimator for a Ratio.

- $\mathrm{Var}(\hat{R}) = [1/\hat{X}2] * \Sigma h\ [nh/(nh-1)] * \Sigma i\ (\hat{Y}hi - \hat{R} * Xhi)2$
- where:
- $\hat{Y}hi = \Sigma j\ \Sigma k\ W'hijk * yhijk$
- $Xhi = \Sigma j\ \Sigma k\ W'hijk * xhijk$

A sample of table salt and a urine sample were collected from the youngest women of reproductive age (aged 15–49 years) in each household. This sampling process followed the principle of administrative hierarchy, starting from the province, municipality, and commune down to the neighborhood, where the census sections were composed of the surveyed households (Fig. 1).

Inclusion and exclusion criteria for participants

The following inclusion and exclusion criteria were used:

Inclusion criteria

- Households residing within the selected census areas, based on the 2014 Angola General Population and Housing Census data.
- Households that agreed to participate in the study.
- Households with women of childbearing age as residents.
- Women who were aware of their pregnancy status (pregnant or non-pregnant), to allow for comparison of iodine levels between these groups.

Exclusion criteria

- Households that refused to participate in the study.
- Households with incomplete or inconsistent data.
- Individuals with known medical conditions affecting iodine metabolism (e.g., thyroid disorders).

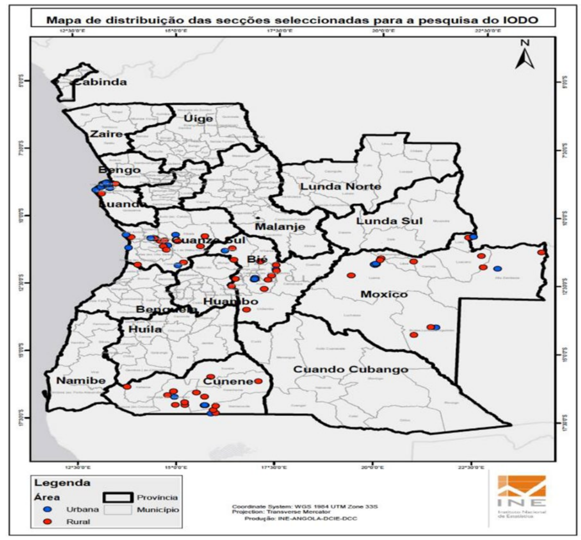

Fig. 1 Geographic distribution of urban (blue circle) and rural (red circle) census sections selected and surveyed for iodine status, Angola, 2019

- Individuals who had recently taken iodine supplements, which could distort the results.

Data collection and samples laboratory analysis

We administered a household questionnaire to either the householder or another knowledgeable adult, as well as the youngest woman of reproductive age (WRA) in the home. The questionnaire included inquiries to assess socio-economic status and the family's iodized salt consumption. In each household, a small sample of cooking salt (25–50 g) was requested and divided into two parts. One part was tested on the spot to identify iodized salt, while the other part was stored in Ziploc sachets for later quantitative analysis. Subsequently, an individual questionnaire was administered to each eligible woman. The questionnaire gathered information on the woman's parity, household size, current breastfeeding status, and her consumption of salted, dried fish and meat (beef, goat, pork, or even game) on the previous day.

Sample collection, transportation and storage

Urine

A random urine sample was collected from each woman of childbearing age within the household, using a 50 mL sterile plastic wide-necked urine container, which was then tightly sealed. The container was properly labelled with the household code for identification purposes. Using a Pasteur pipette, 10 mL of urine was transferred into a 15 mL centrifuge tube, which was labelled with the corresponding household code number and hermetically sealed with a screw cap to facilitate transportation and storage. The centrifuge tubes containing the urine samples were stored in a cooler at a temperature of +2 to +8 °C, from the time of collection and storage in Luanda until shipment to Dar es Salaam, Tanzania. The collected urine samples were transported by air in a refrigerated container maintained at a temperature of +2 °C.

Salt

A 25-g sample of salt granulated (either fine or coarse) was collected, representing the salt used within the household during the previous 24 h. A portion (3–5 g) of the salt was tested on-site for the presence of iodine using a Rapid Test Kit (RTK). This involved applying a drop of RTK solution (white-cap starch reagent). A colour change to blue or purple was considered a positive result. If no colour change occurred, that portion of salt was discarded. Then, from the same salt sample, another portion of salt was selected, and the following procedure was performed: 2–3 drops of acid (red-cap reagent) were applied to the salt portion, immediately followed by 1 or 2 drops of starch solution on top of the acid drop. If the mixture turned blue, iodine was present. If no blue colour appeared within 5 min (maximum time), the result was considered"negative,"indicating the absence of iodine. Rapid Test Kits (RTKs) can only differentiate between the presence and absence of iodine in salt, but they do not determine whether the salt is adequately iodized [8]. The remaining salt sample was packaged in a Ziploc bag, labelled with the household code number, for laboratory analysis. The samples were stored in a dry place (cardboard box) at room temperature until shipment to Dar es Salaam, Tanzania.

We used a separate questionnaire for salt-producing companies, gathering information on production, iodization, packaging, handling, and supply of salt to various parts of the country. Salt samples were also collected for rapid testing, and a portion was packaged and sent to Tanzania for iodine titration.

The iodine content of the salt was quantitatively measured using titration iodometry, as described by De Maeyer EM, Lowenstein, FW, and Thily, CH [9], at the Iodine Laboratory of the Tanzania Food and Nutrition Centre (TFNC). Urinary iodine concentration (UIC) was determined through ammonium persulphate digestion with spectrophotometry, based on the Sandell Kolthoff reaction, Pino et al. modification, 1996, WHO, 2007[10], by the Biochemistry Laboratory at the same Centre.

The analysis utilized internally checked quality control (QC) materials, covering low, medium, and high iodine concentrations run within and between the assays. The internal QCs were established under the guidance of external QCs from the Equip program, conducted by the Centre for Disease Control (CDC).

Assessment of salt status and iodine status

To assess the iodine status of the population, both salt and urine samples were collected and analysed. Salt samples were titrated to determine iodine concentration, with results categorised as non-iodised, inadequately iodised, adequately iodised, or over-iodised, based on established ppm thresholds. Population iodine status from salt was determined by assessing the percentage of households using adequately iodised salt, stratified by zone and area (urban/rural). Urine samples were analysed to determine urinary iodine concentration (UIC). In non-pregnant women, median UIC values were used to classify iodine status as severe, moderate, mild deficiency, adequate intake, or excessive intake, with an additional criterion regarding the percentage of samples below 50 μg/L. In pregnant women, median UIC values were similarly used to determine iodine status, categorising it as insufficiency, adequate intake, above requirements, or excessive intake, also with an additional criterion for low concentration samples. These classifications, presented in the Table 2 provide a standardised framework for evaluating iodine status within the study population.

Data management and statistical analysis

Data collected from field questionnaires were initially entered into CSPro version 7.0 (U.S. Census Bureau, Washington, DC, USA). Laboratory data were subsequently entered into Microsoft Excel version 2013. All data were then imported into SPSS version 23.0 (IBM Corporation, New York, USA) for statistical analysis.

To account for the complex survey design, standardized statistical weights were calculated for each stratum or target group. These weights were applied throughout the analyses to ensure estimates were representative of the target population.

The statistical precision of prevalence rates and median values was assessed using 95% confidence intervals (CIs). A p-value of 0.05 was used to determine statistical significance. To further validate the statistical findings, bootstrap resampling was employed.

Iodine status was evaluated by calculating the median Urinary Iodine Concentration (UIC) for each target group and relevant subgroups, with results interpreted according to World Health Organization (WHO) criteria [9]. Differences in median UIC between subgroups were assessed using the non-parametric Mann–Whitney U test. For both non-pregnant and pregnant women, median UIC values and their respective ranges (minimum, maximum) were determined and reported.

Table 2 Salt Iodine Titration Classification and Urine Iodine in Non-Pregnant and Pregnant Women Status

Iodine Concentration (ppm)	Salt Classification*
Less than 5 ppm	Non-iodised salt
5 ppm to 14.9 ppm	Inadequately iodised
15 ppm to 40 ppm	Adequately iodised
More than 40 ppm	Over-iodised
*Urine Samples: Iodine Status in Non-Pregnant Women***	
Median UIC (µg/L)	**Iodine Status**
< 20 µg/L	Severe iodine deficiency
20—49 µg/L	Moderate iodine deficiency
50—99 µg/L	Mild iodine deficiency
100—299 µg/L	Adequate iodine intake
≥ 300 µg/L	Excessive iodine intake
*Urine Samples: Iodine Status in Pregnant Women****	
Median UIC (µg/L)	**Iodine Status**
< 150 µg/L	Iodine insufficiency
150—249 µg/L	Adequate iodine intake
250—499 µg/L	Above requirements
≥ 500 µg/L	Excessive iodine intake

[*] A population is considered to have good iodine status if over 90% of households use adequately iodised salt

[**] No more than 20% of UIC samples should be below 50 µg/L

[***] No more than 20% of urine samples should have an iodine concentration below 50 µg/L

Ethics and consent

Ethical approval for the research was obtained from the Ethics Committee of the Ministry of Health of the Republic of Angola (Resolution nº 18/2019 of 20 April) and the Director of the INE to conduct the survey. The research and its purpose were preceded by information and official dissemination to the local administrative authorities, who then mobilized the communities for voluntary adherence. Informed verbal consent was obtained from the head of the family or their suitable substitute. For individual questionnaires and urine collection, written informed consent was requested from the participating women. Confidentiality of information from the participants was upheld with utmost care throughout the data collection exercise, processing, and analysis. The results of the rapid iodization test for household salt were immediately communicated, with advice and answers to all questions asked by household members. Authorization letters were signed by the Minister of Fisheries and the Minister of Health to allow the dispatch by private courier of 2225 urine specimens and 2225 salt samples from Angola to the Tanzania Food and Nutrition Centre's reference laboratory for analysis.

Results

Participants'characteristics

A total of 2250 previously selected households were visited, with 2225 (98.8%) women of reproductive age participating in the study. They successfully answered the questionnaire and provided samples of urine and household salt for laboratory analysis of iodine content. Luanda, the capital of the country, had the highest number of women of reproductive age residing in the urban area 438 (95.2%), while Cuanza Sul, in the central region, had the largest number of women residing in the rural area 322 (71.6%).

At the national level, the frequency of pregnant women was 16.9%, the average number of births per woman was three, and the average household size was four members, showing a distribution without significant disparities between provinces. Male-headed households were predominant (71.1%). Most women were single (38.7%) or living with partners without civil marriage (37.8%). About 17.8% of the women reported having no education at all. The intake of dry salted fish was highest in Moxico (42.3%) and lowest in Cunene (16.4%). The intake of salted dry meat was highest in Cunene (15.5%) and lowest in Bie (6.9%) (Table 3).

Table 3 General characteristics of households and women of reproductive age surveyed for iodine status, Angola, 2019

Characteristics			Provinces of Angola				
		All 5 provinces N = 2225	**Luanda n = 460**	**Cuanza Sul n = 450**	**Bié n = 451**	**Cunene n = 446**	**Moxico n = 418**
Residence areas (n, %)	Urban	1198 (53.8)	438 (95.2)	128 (28.4)	236 (52.3)	205 (46.0)	191 (45.7)
	Rural	1027(46.2)	22 (4.8)	322 (71.6)	215 (47.7)	241 (54.0)	227 (54.3)
Average births/woman (min, max)		3.0 (0 –12)	2.1 (0–11)	3.0 (0 –11)	3.2 (0 –12)	3.2 (0–12)	3.2 (0 –12)
Average household size(min, max)		4.6 (1–13)	4.6 (1–13)	4.9 (1–12)	4.8 (1–11)	4.3 (1- 12)	4.3 (1–10)
Pregnant woman (n,%)	Yes	377 (16.9)	85 (18.5)	64 (14.2)	68 (15.1)	75 (16.8)	85 (20.3)
	No	1848 (83.1)	375 (81.5)	386 (85.8)	383 (84.9)	371 (83.2)	333 (79.7)
Previous salted dry fish intake (n,%)	Yes	600 (27.0)	102 (22.2)	127 (28.2)	121 (26.8)	73 (16.4)	177 (42.3)
	No	1625 (73.0)	358 (77.8)	323 (71.8)	330 (73.2)	373 (83.6)	214 (57.7)
Previous salted dry meat intake (n, %)	Yes	274(12.3)	64 (13.9)	62 (13.8)	31 (6.9)	69 (15.5)	48 (11.5)
	No	1951 (87.7)	396 (86.1)	388 (86.2)	420 (93.1)	377 (84.5)	370 (88.5)

Coverage of households with iodized salt

It was not possible to know the sources of the salt provided, as the separate samples were supplied in containers used in the kitchen. Only 29.3% (95% CI 27.5, 31.2) of households had adequately available iodine salt. Most of the salt supplied was not iodized (29.9%) or inadequately iodized (40.1%) according to international standards. Only 0.7% of this salt had excessive iodine (> 40 ppm).

The difference between the coverage of adequate iodized salt of urban and rural households is not relevant as the respective 95% CIs are almost overlapping (43.9, 51.5 and 47.5, 55.1). However, there was a notable difference between provinces, as Luanda, the country's capital, with the largest urban area, had less coverage (16.6%) of adequately iodized salt than inland provinces such as Cuanza Sul and Moxico, with 22.4% each. Finally, the coastal zone (46.2%) followed by the central zone (33.9%) had greater coverage of adequately iodized salt (Table 4).

Table 4 Distribution of household salt iodine levels and of adequately iodized salt, Angola, 2019

Characteristic	n	%	(95% CI)[B]	*p* Value[C]
Salt Iodine status distribution				
Not iodized (< 5.0 ppm)	665	29.9	(28.2, 31.8)	< 0.001
Inadequately iodized (5—14.9 ppm)	892	40.1	(38.1, 42.1)	
Adequately iodized (15—40 ppm)[A]	652	29.3	(27.5, 31.2)	
Excessive iodine (> 40 ppm)	16	0.7	(0.4, 1.2)	
Adequately iodized salt[A], by residence				
Urban	311	47.7	(43.9, 51.5)	< 0.001
Rural	341	52.3	(47.5, 55.1)	
Adequately iodized salt[A], by Provinces				
Luanda	108	16.6	(13.9, 19.6)	0.001
Cuanza Sul	146	22.4	(19.4, 25.6)	
Bie	126	19.3	(16.5, 22.5)	
Moxico	146	22.4	(19.4, 25.6)	
Cunene	126	19.3	(16.5, 22.5)	
Adequately iodized salt[A], by zone				
Coastal	301	46.2	(42.4, 50.0)	0.022
Central	221	33.9	(30.4, 37.6)	
Eastern	130	19.9	(17.1, 23.2)	

[A] Adequately iodized defined as containing 15–40 ppm iodine (n = 652); [B] CI = confidence interval; [C] Chi-square *p*-value indicates that the proportion in at least one subgroup is statistically different from the values in the other subgroups

Salt iodization status in main salt producing companies

According to national legislation, salt must have an iodine content ranging from 25 to 55 ppm at the point of production or import. However, out of the five companies visited, only one, one had salt within the recommended range. The iodine content in their salt was 33.9 ppm. Salt from two companies had very low iodine content (8.5 and 6.5 ppm, respectively). On the other hand, salt from the remaining two companies, from Benguela, had extremely high concentrations of iodine (507.8 and 1764.7 ppm, respectively). Except for the two companies in Benguela, the other companies were not regularly inspected and their salt packs were not marked with iodine specifications, as shown in Table 5.

Iodine status among women of reproductive age

We collected urine samples from 2225 women, including 377 pregnant and 1848 non-pregnant women, to assess their iodine levels. The median urinary iodine concentration (UIC) was slightly lower in pregnant women (102.2 μg/L) compared to non-pregnant women (108.2 μg/L), though this difference was not statistically significant

Table 5 Status of the salt iodine supplied by the national reference salt producing companies in Angola, 2019

Companies and Provinces where located	Salt iodine content(ppm)	Status	Regular inspection	Original packing with iodization mentioned
C1—Namibe	33.9	Within range	Sometimes	No
C2—Namibe	8.5	Low	Sometimes	No
C3 – Bengo	6.3	Low	Sometimes	No
C4—Benguela	1764.7	Extremely high	Yes	Yes
C5—Benguela	507.8	Extremely high	Yes	Yes

C—Companie

(p =0.346). However, the distribution of iodine levels differed significantly between the two groups. A substantial majority of pregnant women (68.2%) had insufficient iodine levels (below 150 µg/L), indicating potential iodine deficiency. In contrast, the largest proportion of non-pregnant women (44.2%) had adequate iodine levels (100–299 µg/L). Notably, 17.4% of all women had UIC levels below 50 µg/L, which suggests a broader issue of iodine deficiency within the population. While both groups showed a wide range of UIC values, with some women having very high levels, the overall data highlights that pregnant women are significantly more likely to have insufficient iodine compared to non-pregnant women (see Table 6).

The distribution of Urinary Iodine Concentration (UIC) between pregnant and non-pregnant women was visualised using a bar chart (Fig. 2). A notable trend was observed whereby both pregnant and non-pregnant women exhibited a higher frequency of UIC values within the lower concentration ranges, particularly 50–99 µg/L and 100–149 µg/L. Consistently across all UIC categories, the number of pregnant women was lower than that of non-pregnant women. The overall trend demonstrated a decline in the number of observations as UIC values increased, indicating that higher UIC levels are less prevalent in both groups. A slight elevation in the number of non-pregnant women was observed in the > = 600 µg/L category, suggesting a potential outlier within this range.

Discussion

The initial intention was to conduct an IDD survey with national coverage, but a shortage of resources necessitated limiting the coverage to five provinces out of the country's 18 provinces. Even though 2252 households were surveyed, only 27 (1.2%) were dropped, which was lower than the 5 percent allowed [11]. Pregnant women made up 17 percent, consistent with the expected proportion for a third-world country [12]. Most households were male-headed, highlighting the need to include men in education on salt iodization. Approximately 18 percent of women had no education at all, emphasizing the importance of simplifying and organizing education and sensitization on iodized salt to ensure uneducated women also benefit. The main measure to solve iodine

Table 6 Distribution of UIC levels in the women

UIC Category (µg/L)	Pregnant Women (n = 377)	Non-Pregnant Women (n = 1848)	Statistical Comparison*
Median UIC (µg/L)	102.2	108.2	U = 334723.5 W = 405976.5 $p = 0.231$
Range (Min–Max)	5.5–2562.4	4.5–4802.7	–
Insufficient (< 150)	257 (68.2%)	860 (46.5%)	U = 152971.5 W = 186124.5 $p = 0.568$
Severe (< 20)	–	78 (4.2%)	–
Moderate (20–49)	–	244 (13.2%)	–
Mild (50–99)	–	538 (29.1%)	–
Adequate (100–299)	78 (20.7%)	817 (44.2%)	U = 61168.5 W = 74048.5 $p = 0.199$
Above Recommended (250–499)	20 (5.3%)	–	–
Excessive (≥ 500)	22 (5.8%)	171 (9.3%)	U = 774.0 W = 1027.0 $p = 0.48$

* Wilcoxon–Mann–Whitney U test (two independent samples) comparison of median values

Mann–Whitney **U** (Test statistic)

Wilcoxon **W** (Test statistic)

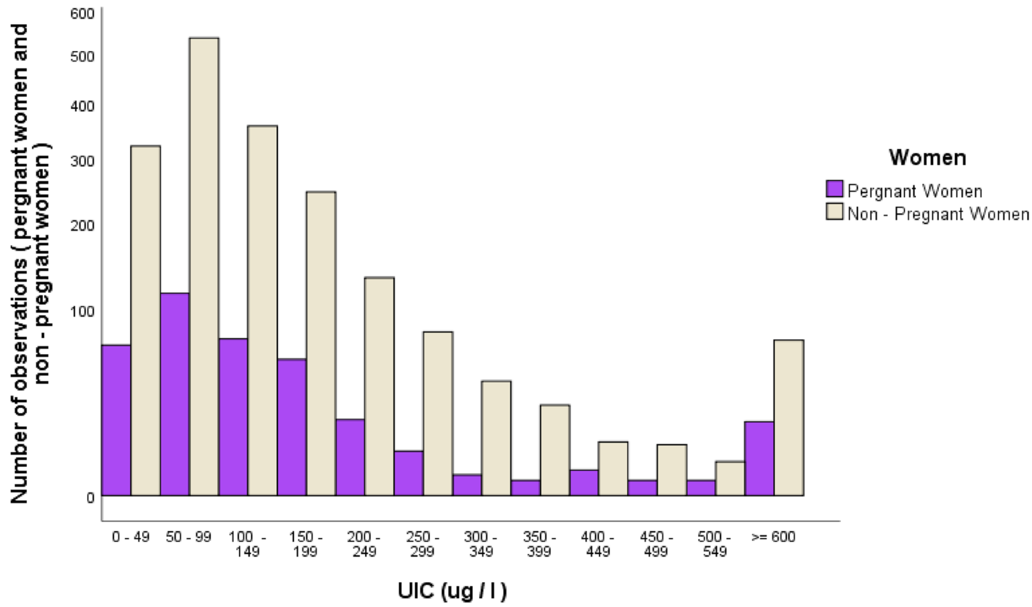

Fig. 2 Frequency distribution of UIC of pregnant and non-pregnant women

deficiency and disease is to reinforce the worldwide recommendation that all salt must be iodized.

Thirty percent of households were using salt with no iodine, and 40 percent were using inadequately iodized salt. Only 29 percent were using adequately iodized salt, while a small proportion was using excessively iodized salt [13]. Furthermore, some salt-producing companies were not adhering to the requirements of proper salt iodization and packing. Salt is considered adequately iodized when the fortification level is 15–40 ppm iodine in salt. In a similar study carried out by Ketwa et al. [14] in Lubumbashi, Democratic Republic of Congo, the authors found that almost fourteen percent of households were using non-iodized salt, and almost forty-five percent were using sufficiently iodized salt. Angola has more inequalities regarding iodized salt consumption within, but overall, our country is classified as having adequate iodine intake [15].

Although mUIC is a recommended indicator of iodine status in populations, its value for assessing individual status is limited by high day-to-day variability in iodine intakes. The reach of the iodized salt program in Angola is remarkable, as it was established in the 90 s. The results found in this study remind us that Angola has the same pattern as other Western and Central African countries, with one out of four households using iodized salt [15].

Low consumption of adequately iodized salt was reflected in low UIC in women of reproductive age. In pregnant women, the median value of UIC was lower than the recommended level, indicating iodine deficiency. However, in non-pregnant women, the UIC median value met the recommended level with a small margin, and the proportion of those with UIC less than 50 μg/L was below 20 percent, indicating iodine sufficiency. UIC frequency distribution curves in both maternal states showed most observations lying below the median values. Therefore, caution must be taken when assuming Angola has an iodine deficiency, as there is wide iodine intake variation leading to varying UIC values, sometimes falling below adequate levels [16–18].

Another significant source of iodine is food, with dried fish and meat being the main sources as found in various studies [19, 20]. In our study, we discovered that at least one out of four households consumed salted fish or dried salted meat, with rates as high as 42% in some provinces. Angola's long coast allows for the production of dried salted fish in various regions. Given the iodized salt produced in Angola, it is essential to test if the iodine levels in dried salted fish or meat meet the required standards. Therefore, further studies are needed in this area to ensure that salt used in salted foods is adequately iodized.

The significant variation in adequately iodised salt coverage across Angolan provinces reveals a complex and concerning picture. The low coverage observed in Luanda, the country's capital, is particularly alarming, contrasting sharply with the higher coverage found in Cuanza Sul and Moxico. This finding suggests that urbanisation and administrative centralisation do not, on their own, guarantee access to essential public health goods, such as adequately iodised salt. Regional disparities highlight challenges in the distribution and enforcement of iodised salt standards. Factors such as logistical infrastructure, the presence of informal markets, and socioeconomic differences can all influence the availability and access to iodised salt. The concentration of iodised salt production in certain provinces may exacerbate inequalities, especially in remote or transport-challenged areas [21].

The need for targeted interventions is evident. Strategies to strengthen enforcement, improve distribution, and promote equitable access to iodised salt are crucial to safeguarding the health of the Angolan population. Collaboration between the government, salt-producing companies, and local communities is essential to overcome these obstacles and achieve universal salt iodisation[22–24].

Analysis of salt from Angolan companies revealed extreme variations in iodization. Two companies showed excessively high levels, while three others had insufficient iodization. The Ministry of Fisheries, as the regulatory body, is responsible for conducting regular inspections of salt production. This oversight process primarily focuses on three key areas: visual inspections to assess general production and packaging conditions; analysis of company-provided reports detailing iodisation and quality control procedures; and the use of rapid iodine tests to verify the presence of iodine in salt. However, quantitative assessment of iodine concentration, which requires the use of more sophisticated laboratory equipment and techniques, is carried out sporadically. The main reason for this limitation is the scarcity of technical resources and adequate laboratory infrastructure to perform accurate and frequent analyses.

Despite limitations due to a small sample size, this study represents the first large nationwide study on salt use and UIC in pregnant and non-pregnant women in Angola. The results provide insight into the population's iodine status and fill a gap in the literature regarding iodine information [25].

Conclusion

This survey, conducted across five provinces, revealed significant disparities in iodine status within the studied population. While approximately three-quarters of households reported using salt containing some iodine, less than one-third used salt that was adequately iodized, according to established standards. Notably, the study identified a clear distinction in iodine intake between non-pregnant and pregnant women of reproductive age. Non-pregnant women generally demonstrated sufficient iodine intake. However, a substantial proportion of pregnant women exhibited insufficient iodine levels. These findings highlight a critical public health concern regarding the adequacy of iodine intake, particularly among pregnant women, and underscore the need for targeted interventions to address these deficiencies.

Acknowledgements
The authors thank Fernando Nioca, Manuel Cacharamba, Engrácia Lopes, António João, Benjamim Nsakala Nzinga Mateus, Madalena Sango, and Luísa Francisco for their contributions during data collection in the communities, and to the Provincial Governments of Luanda, Moxico, Cuanza Sul, Bié, and Cunene for the institutional support provided during the data collection phase. The authors sincerely thank Dr. António Oliveira for his collaboration on the statistical review of this article, whose expertise significantly contributed to the accuracy of the results.

Institutional review board statement
The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Ministry of Health with protocol code n. 18/2019 on April 20 th.

Author contributions
Conceptualization, E.C., E.F., and T.N.; writing—original draft preparation, E.C., E.F., T.N., A.K., S.K., F.B., V.N., O.C., N.C., and F.F.; writing—review and editing, all authors have read and agreed to the published version of the manuscript.

Funding
This work was supported by UNICEF and Government of Angola under contract number 43252845.

Data availability
The original data presented in the study are openly available through the authors. No datasets were generated or analysed during the current study.

Declarations

Informed consent
Informed consent was obtained from all subjects involved in the study.

Competing interests
The authors declare no competing interests.

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Received: 13 December 2024 Accepted: 27 April 2025
Published online: 24 May 2025

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