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Iodine deficiency persists in the Zanzibar Islands of Tanzania

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Commentary

Tanzania has, over the past decade, made good progress toward universal salt iodization, but the most recent information and data reported by the World Health Organization (WHO) and UNICEF, and published in the regular "scorecard" of progress by the Network for Sustained Iodine Nutrition (http://206.191.51.240/Resources_Nutrition.htm), indicates that only 73.8% of households have access to iodized salt. Moreover, only 67% of the accessible salt is satisfactorily iodized to optimal levels. However, Tanzania has a functioning National Committee, appropriate legislation is in place, and a national officer responsible for salt iodization has been appointed. The country has also committed to assessing national progress in iodization coverage at least every five years.

The study by Assey et al. confirms the well-known fact that populations living on islands or near seacoasts are not free from iodine-deficiency disorders. It has long been known that such populations are in need of daily intake of iodine. Nor are iodine-deficiency disorders limited to developing nations; they are a danger wherever iodine has been depleted from the soil. The most economic, efficient, and effective method of delivering iodine to the population every day in every village is via iodized salt.

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Abstract

Background. *Iodine is an essential micronutrient for normal human growth and development. It is estimated that more than 1.6 billion people live in iodine-deficient environments, yet there are still some countries and areas where the prevalence of iodine-deficiency disorders is unknown.*

Objective. *To establish the prevalence of iodine-deficiency disorders in the Zanzibar Islands, a community assumed to have ready access to iodine-rich seafoods.*

Methods. *In a cross-sectional study, 11,967 schoolchildren were palpated for goiter prevalence, a subsample was evaluated for urinary iodine concentration, and the availability of iodated salt was assessed at the household and retail levels.*

Results. *The mean total goiter prevalence was 21.3% for Unguja and 32.0% for Pemba. The overall median urinary iodine concentration was 127.5 μg/L. For Unguja the median was 185.7 μg/L, a higher value than the median of 53.4 μg/L for Pemba ($p < .01$). The household availability of iodated salt was 63.5% in Unguja and 1.0% in Pemba. The community was not aware of the iodine-deficiency problem and had never heard of iodated salt.*

Conclusions. *The inadequate intake of iodine documented in the Zanzibar Islands belies the common assumption that an island population with access to seafood is not at risk for iodine-deficiency disorders. We urge health planners to implement mandatory salt iodation and education efforts to alleviate the situation.*

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Introduction

Iodine is an essential micronutrient for normal human health and development. It is found in the soil and seawater and is transferred to humans through the food chain. Iodine deficiency is characterized by a slowdown of metabolic processes, which in children translates into a deficit of growth and development [1, 2]**.** The World Health Organization (WHO) estimates that more than 1.6 billion people live in iodine-deficient environments [2, 3]. These environments are in highlands and flood-prone areas where the soil becomes iodine deficient as a result of erosion and leaching. In 1999, WHO/UNICEF/ICCIDD classified 130 of 191 countries as having iodine-deficiency disorder problems, 20 as having eliminated the problem, and the remainder as having an unknown level of iodine-deficiency disorder problems [4].

On the basis of a large series of local and district goiter surveys conducted among schoolchildren in 1980–90 in mainland Tanzania, about 10 million people were estimated to be at risk for iodine-deficiency disorders, and an estimated 5.6 million people were suffering from endemic goiter [5]. Interventions undertaken since the mid-1980s included large-scale oral iodine supplementation and universal salt iodation [6]. Recent iodine-deficiency disorder evaluation survey reports from 16 endemic districts showed a substantial increase in the consumption of iodated salt and a concomitant reduction in goiter prevalence [7].

Zanzibar, consisting of the islands of Unguja and Pemba, with a total area of 2,332 km^2, is part of the United Republic of Tanzania* (**fig. 1**). Zanzibar was not covered by goiter surveys and interventions conducted by the Tanzania Food and Nutrition Centre (TFNC), because it was assumed that populations surrounded by ocean have adequate iodine status from the consumption of seafood such as fish, crabs, snails, and sea plants rich in iodine [1, 8].

In 1998, 31 goiter cases were reported from Zanzibar after screening for visible goiter in Pemba South District; 84% of the patients were women.** This report alerted the TFNC to the need for a formal assessment in both islands. The present study was designed to establish the prevalence of iodine deficiency in the Zanzibar Islands and to identify possible etiological factors. As far as we know, this is the first study of iodine deficiency in the Zanzibar Islands.

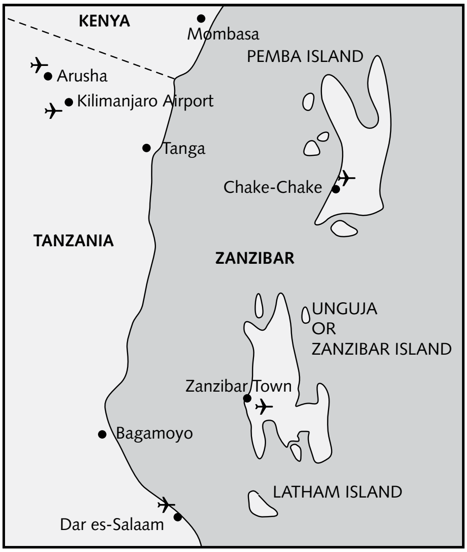

FIG. 1. Map of Zanzibar showing the islands of Unguja and Pemba

Subjects and methods

Study area, population, and sample size

This cross-sectional study was conducted on the two islands of Zanzibar, Unguja and Pemba, and covered primary schoolchildren from 10 districts. All primary schools on the islands were allocated to one of three stratified geographic divisions described by local residents as highlands, lowlands, and townships. Such strata are known to be related to iodine status [1]. In each of the 10 districts, two schools were randomly selected for each stratum, resulting in a total of 60 schools surveyed. Since this was a baseline survey, three major iodine-deficiency disorder indicators were assessed to reflect the magnitude of the problem—goiter prevalence, urinary iodine concentration, and household availability of iodated salt—as a basis for planning future interventions and evaluating their impact. In each school, 200 children were systematically selected on the basis of the proportional number of children in each class and were palpated for goiter [9]. A subsample of 10 children from each school was systematically selected at 1/20th interval of sample children (i.e., every 20th child was selected) to give urine samples for determination of urinary iodine concentration levels [9, 10]. To determine the availability of iodated salt at the household level, one child

* The United Republic of Tanzania is a union of two governments (Tanzania Mainland and Zanzibar) with some independent ministries for each government, such as Health and Social Welfare. The health priorities of the different ministries are not necessarily the same.

** Government of Zanzibar. Speech by the Minister of Health to the Revolutionary Council of the House of Representatives, Zanzibar, July 1999.

from each household brought a tablespoonful of salt for iodine testing and was also asked about his or her awareness of iodated salt.

Shops selling salt were also assessed for the presence of iodated salt, with a convenience sample of 5 to 10 shops for each of the 10 districts. In addition, in each village with a school that had been selected for the goiter survey, shopkeepers were interviewed and community members participated in a group discussion. A convenience sample of 80 salt samples was collected from shops and analyzed for iodine content.

Knowledge, attitudes, and practices relating to iodine-deficiency disorders and iodated salt were assessed among the shopkeepers and the community members. A semistructured questionnaire was used to collect data from the shopkeepers. Focus group discussions were conducted in a convenience sample of adult members of the community with the use of a discussion guide.

Iodine status measurement procedures

Goiter assessment was performed to measure the long-term iodine status of the population. Primary schoolchildren were chosen as the group to measure, as is commonly done in goiter surveys. An experienced medical nutritionist palpated and graded goiters according to the WHO goiter classification criteria of Perez and Scrimshaw [11, 12], which offers increased specificity [13], and also allow for a more direct comparison to previous surveys conducted in Tanzania [5]. Children were classified as having goiter if the thyroid size was of grade 1a, 1b, 2, or 3; a palpable goiter was defined as grade 1a when one lobe was deemed larger than the terminal phalanx of the child's thumb [11, 13].

Urinary iodine concentration levels were determined by the Sandell-Kolthoff reaction using the spectrophotometric ammonium persulfate digestion method with a lower limit of detectability of 0.0034 μg of iodine. A coefficient of variation of less than 5% was obtained, which compares well with the inductively coupled plasma mass spectrometric (ICP-MS) method that aims for a coefficient of variation less than 10% [10, 14].

Salt samples from the households were tested semi-quantitatively in the presence of the child using a rapid test kit for iodate (MBI Kit) that causes the color of the salt to change to blue if the iodine content is 15 ppm or more. Salt samples from shops were assessed for iodine levels by the iodometric titration method [10, 15].

Data analysis

The qualitative data were analyzed by content analysis, whereas the quantitative data were analyzed by SPSS (version 10). Mean ± SD and median values were calculated for continuous data and frequencies for categorical data.

Ethical approval and informed consent

The study proposal was approved by the Ministry of Health and Social Welfare Committee on Research on Human Subjects. Two of the authors explained the purpose and requirements of the study to the children, primary schoolteachers, and community members. Only those children and community members who gave informed consent participated in the study. Fifty children declined to participate.

Results

Sample characteristics

Information on goiter prevalence was collected from 11,967 children: 7,101 from Unguja and 4,866 from Pemba. The average age was 12 years (range, 6 to 18 years), and 48.9% were male.

Goiter prevalence

Table 1 provides data on goiter palpation results, urinary iodine concentration, and availability of iodated salt at the household level by district for the two islands. In Unguja, where the land is mostly flat, 3.8% of children had visible goiter and the total goiter prevalence was 21.3%. In Pemba, which is made up of hills and escarpments, 8.8% had visible goiter and the total goiter prevalence was 32.0%. These results indicate the presence of a moderate iodine-deficiency disorder problem on Unguja and a severe problem on Pemba [9]; the environmental influence on iodine deficiency was more obvious in Pemba than in Unguja.

The relations between goiter grades 1a and 1b and visible goiter were different in the two islands. In Pemba, thyroid size was larger, as indicated by a high prevalence of visible goiter and a higher prevalence of grade 1b goiter than of 1a goiter. Goiter prevalence was

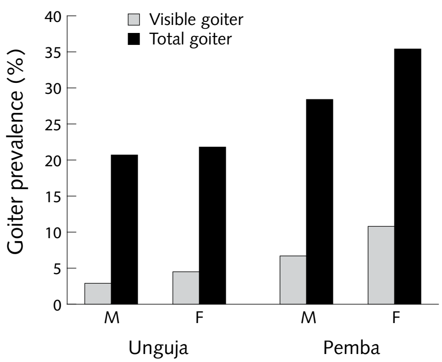

FIG. 2. Goiter prevalence among male and female schoolchildren in Unguja and Pemba Islands

TABLE 1. Indicators of iodine deficiency among primary schoolchildren in districts in the islands of Zanzibar[a]

District	No. of children sampled	Goiter prevalence (%)				Urinary iodine		Availability of iodated salt	
		Grade 1a	Grade 1b	Visible goiter[b]	Total goiter[c]	Samples analyzed	Median (μg/L)	No. of households sampled	% with iodated salt
Unguja Island									
Urban	1,206	7.4	5.6	2.0	15.0	58	282.5	1,641	65.1
West	1,201	6.9	6.2	3.2	16.3	59	218.0	1,041	57.5
Central	1,165	7.0	6.6	3.6	17.2	58	173.9	1,346	65.9
South	1,175	13.6	11.6	3.5	28.7	58	204.9	1,031	51.0
North A	1,208	11.1	10.4	4.6	26.1	65	185.6	1,513	69.4
North B	1,145	9.3	10.1	5.7	25.1	58	121.6	758	66.5
Total	7,101	9.2	8.3	3.8	21.3	356	185.7	7,330	63.5
Pemba Island									
Wete	1,205	13.8	14.8	7.9	36.5	57	63.4	1,890	0.7
Micheweni	1,226	9.5	13.4	8.7	31.6	58	35.1	2,041	0.2
Chakechake	1,224	10.0	11.7	9.6	31.6	47	75.7	2,396	2.0
Mkoani	1,211	8.1	11.6	9.1	28.8	41	50.8	2,167	0.9
Total	4,866	10.3	12.8	8.8	32.0	202	53.4	8,494	1.0
Zanzibar total	11,967	9.6	10.2	5.8	25.6	559	127.5	15,824	30.0

a. Unguja and Pemba Islands are collectively known as Zanzibar.
b. Visible goiter consists of grades 2 and 3 goiter.
c. Total goiter consists of grades 1a, 1b, 2, and 3 goiter.

higher among girls than among boys (**fig. 2**). The sex-related difference in prevalence was more pronounced on Pemba. For Zanzibar as a whole, the prevalence was highest in the 13-to-15-year age group ($p < .05$) (**table 2**).

Urinary iodine concentration

There was a significant difference in urinary iodine levels between Unguja and Pemba ($p < .01$) (**table 1**). The mean values for Unguja and Pemba were 215 ± 145 and 79 ± 80 μg/L, respectively; the mean difference was 136 μg/L (95% confidence interval, 114.5 to 157.8). The median urinary iodine concentration for Unguja was 186 μg/L, and no district had a median value of less than 100 μg/L, the cutoff value for mild iodine deficiency. In Pemba, the median urinary iodine concentration was 53 μg/L (district range, 35 to 76 μg/L), indicating moderate iodine deficiency. The proportion of children with urinary iodine concentrations below 50 μg/L was only 8% in Unguja ($n = 356$) but was 47% in Pemba ($n = 203$). The overall median urinary iodine concentration was higher in boys (139 μg/L, $n = 283$) than in girls (113 μg/L, $n = 176$) ($p < .01$).

Salt iodine content

The findings from 15,824 salt samples from households in 10 districts tested qualitatively for iodine are also presented in **table 1**. Of the 7,330 samples from Unguja, 63.5% had adequate iodine, in comparison with 1.0% of 8,494 samples from Pemba ($p < .01$).

Of 121 salt traders surveyed (81 from Unguja and 40 from Pemba), 58.7% in Unguja and 3.3% in Pemba were selling iodated salt, most of which originated from the Tanzanian mainland. Most of the salt consumed in both islands was coarse salt that was packed in bulk in 50-kg bags without inner linings and sold in the open. This mode of packaging probably increased the loss of iodine from iodated salt. Other salt had been imported by individual salt traders from neighboring countries and was sold nonbranded in retail shops.

Quantitative analysis of the iodine content of 80 salt samples from shops found that iodine levels were very low in comparison with the national retail level requirement of ≥ 37.5 ppm iodine used in mainland Tanzania (**table 3**); the median iodine content was 10.3 ppm ($n = 56$) for Unguja and 2.9 ppm ($n = 24$) for Pemba. Thus, 66% and 79% of all salt samples tested in Unguja and Pemba, respectively, had unacceptably low levels of iodine, whereas 3.7% of samples for Zanzibar as a whole were overiodated (> 100 ppm iodine).

None of the children examined for goiter, and none of the community members, including schoolteachers, had heard of the iodine-deficiency problem or were aware of iodated salt. None of the wholesalers or retail traders were aware of the iodine-deficiency problem. Very few reported ever having heard of iodated salt, despite the fact that many shops in Unguja were stocked with salt labeled "iodated." Fine-ground salt was commonly used in restaurants and by street vendors selling snacks, presumably because it is easier

TABLE 2. Prevalence of goiter in Zanzibar according to age group

Age (yr)	No. of children sampled	Goiter prevalence (%)			
		Grade 1a	Grade 1b	Grades 2 and 3	Total goiter
6–12	6,721	8.1	6.6	3.3	18.1
13–15	4,381	12.3	15.2	9.3	36.9
≥ 16	865	8.0	12.0	7.2	27.2
Total	11,967	9.6	10.2	5.8	25.6

TABLE 3. Proportion (%) of salt samples from shops in Unguja and Pemba islands with unacceptable, low, acceptable, and high levels of iodine[a]

Island	No. of samples	Unacceptable	Low	Adequate	High
Unguja	56	66.1	21.4	8.9	3.6
Pemba	24	79.2	4.2	12.5	4.2
Zanzibar total	80	71.2	15.0	10.1	3.7

a. Levels are defined by the United Republic of Tanzania Salt Acts: Mining Act, 1979; Mining Regulation, 1994 (salt production and iodation); Food Act, 1978 (control of quality); Control of Quality Regulation, 1992 (iodated salt). Unacceptable levels are defined as 0.0–18.4 ppm, low levels as 18.5–37.4 ppm, acceptable levels as 37.5–100.0 ppm, and high levels as > 100.0 ppm.

to use than coarse salt. This type of salt is not locally processed but is imported from neighboring countries and is probably iodated. It was also observed that fishing was very common in the islands.

The main food crops were cassava, rice, vegetables, and a variety of fruits. Cloves and coconuts were the major commercial crops. Seaweed was also produced in some areas for export but was not consumed locally.

Discussion

This study was cross-sectional, offering a snapshot of a dynamic situation in which iodated salt from mainland Tanzania may occasionally be available, leading to temporary improvements in iodine status among those who consume it, but most salt probably continues to come from local non-iodated sources in the absence of legislation requiring salt iodation in Zanzibar.

Quantitative measurements of the iodine content of salt samples from shops on both islands found an overall median value below 18 ppm, the minimum required at the household level in mainland Tanzania.* Pemba is almost solely dependent on its locally produced salt. Its small-scale producers had no knowledge of iodine-deficiency disorders or of salt iodation. The few brands of imported iodated salt were often not marked so that they could be distinguished from local salt samples. They may also have had low levels of iodine as a result of losses from poor handling and storage. The producer education efforts directed to mainland Tanzania [5] were not implemented in Pemba.

Unguja Island, where the main port of Zanzibar is located, has better access to commercial goods and imports much of its salt from countries that have been implementing salt iodization programs for almost a decade. Some of the salt originating from the coastal belt of mainland Tanzania, however, was found not to be iodated, presumably because there was no demand for iodation from Zanzibar.* This allows salt producers to avoid the extra labor required for iodation and also to save their potassium iodate for those buyers who demand iodated salt.

At the moment, none of the indicators listed by WHO for achieving sustainable elimination of iodine-deficiency disorders is fulfilled in Zanzibar [9]. On the basis of total goiter prevalence alone, Zanzibar suffers from a moderate iodine-deficiency disorder problem, presumably caused by lack of adequate dietary iodine intake. The reliability of goiter data can be questionable. There may be intraobserver and interobserver variability in the data [9], but this variability was probably reduced by using one experienced examiner and the WHO goiter criterion [13]. However, goiter prevalence may not reflect current iodine status very well in a situation like that on the Zanzibar Islands, where imported iodated salt may have been available at times [9]. In such a situation, measurement of urinary iodine concentration provides important complementary information [10]. According to WHO, median iodine concentrations should be greater than 100 µg/L in "non-iodine-deficient" populations, and no more than 20% of the population should have a urinary iodine concentration of less than 50 µg/L [9, 16]. These

* The following acts of the United Republic of Tanzania affect the production and quality of salt: Mining Act, 1979; Mining Regulation, 1994 (salt production and iodation); Food (Control of Quality) Act 1978; Control of Quality (iodated salt) Regulation, 1992.

criteria were met in Unguja but not in Pemba, where 47% of urine samples had an iodine concentration of less than 50 µg/L.

Pemba has a higher average altitude than Unguja and a higher goiter rate. Increased rates of iodine-deficiency disorders with increased altitude have been observed elsewhere [1]. However, in this case the lower penetration of iodated salt in Pemba probably explains the difference. Furthermore, even when iodated salt is occasionally available, it is likely to be more available and affordable in towns than in more isolated areas.

As is commonly seen for iodine-deficiency disorders [17], females were more affected than males, particularly in Pemba. The large differences observed between the sexes might not have been expected if, as assumed, the population consumed adequate quantities of iodine-rich seafoods. In addition to a possible physiological explanation, with women having higher iodine demands, males may take more meals or eat more snack foods outside the home, where iodated salt may have been used in food preparation or may be available on restaurant tables. In the culture of Zanzibar, older girls, like their mothers, tend to remain indoors and thus are less likely to consume iodated salt outside the home. As girls begin to bear children, there is a risk of fetal and neonatal deficiencies, which can lead to brain damage from iodine deficiency [17–19]. This calls for special iodine surveys targeting women of childbearing age [20].

The low median urinary iodine levels in Pemba suggest low dietary intake of iodine from the foods locally consumed. This finding is similar to those from some Pacific islands [21, 22]. Thus, assumptions should not be made about the iodine status of populations living close to the sea. In this case, iodated salt may be the only sustainable alternative for improving the population's iodine status, since salt is the only processed food item consumed daily by most islanders.

Goiter prevalence levels were high on both islands, although urinary iodine levels were normal in Unguja but not Pemba. This is to be expected, because goiter levels take many years to normalize once iodine intakes increase after long periods of being suboptimal [9, 12]. In Unguja, the availability of iodated salt as an opportunistic intervention has presumably occurred recently, probably as a result of the effective implementation of an iodine-deficiency disorder control program in mainland Tanzania.

Goiter can also be caused by food rich in goitrogens, such as bitter cassava. Cassava increases the level of thiocyanate, the end product of cyanide detoxification in the human body, which has been shown to competitively interfere with iodine uptake in the thyroid gland in experimental studies [23, 24]. However, even populations with very high dietary thiocyanate intake from insufficiently processed cassava do not develop goiter if iodine intake is adequate [25, 26]. Although people in Zanzibar consume cassava, we do not know the extent to which this may contribute to the prevalence of goiter on the islands. The low urinary iodine concentrations observed in the high-goiter areas suggest that cassava is not a major contributing factor.

Another possible contributing factor to the etiology of the iodine-deficiency disorder problem in Zanzibar is iron-deficiency anemia. On Pemba Island, the prevalence of anemia among children was found to be 62.5%, of which 51.5% was due to iron deficiency [27]. It has been suggested that concurrent iron-deficiency anemia impairs the therapeutic response to iodine supplementation, possibly as a result of decreased conversion of thyroxine (T_4) to triiodothyronine (T_3) or through decreased thyroperoxidase activity, impairing iodide organofication [28, 29]. Thus, iron deficiency is associated with a high prevalence of goiter [30].

The endemic goiter seen on both islands shows that access to seafood has not protected the population against iodine-deficiency disorders, although such protection has often been assumed [1, 8, 12]. Although the islands of Zanzibar are small and have a high rainfall, the amount of iodine brought to the soil by rain may be smaller than the requirement; hence, no natural correction can take place and iodine deficiency is likely to persist indefinitely [1]. Measures for combating iodine deficiency required in these islands include raising public awareness, ensuring easy access to iodated salt, and promoting compliance with iodation in the salt industry by legislating mandatory iodine fortification of all salt, as well as monitoring and enforcement of the legislation [31]. We urge health and nutrition program planners not to assume, as we did, that iodine deficiency is not a public health problem in islands; only iodine-deficiency surveys can determine whether this problem exists.

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* The Government of Zanzibar has no salt iodation regulation, which is widely considered to be mandatory for iodine-deficiency disorder control programs [9].

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