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URINARY IODINE CONCENTRATION AND AVAILABILITY OF IODATED SALT IN SCHOOL CHILDREN IN A GOITRE-ENDEMIC DISTRICT OF TANZANIA
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URINARY IODINE CONCENTRATION AND AVAILABILITY OF IODATED SALT IN SCHOOL CHILDREN IN A GOITRE-ENDEMIC DISTRICT OF TANZANIA

K.B.M. KULWA, K. KAMUZORA and G. LEO

ABSTRACT

Objectives: To determine the iodine status of school children and document the availability, price, use and storage of iodated salt in Ludewa District, Tanzania.
Design: A cross-sectional descriptive study.
Subjects: One hundred parents and their fifty school children aged eight to ten years.
Setting: Ludewa District of Iringa region, Tanzania in January 2003.
Results: Median urinary iodine concentration of the school children was 86.76 μg/L (range: 21.69 μg/L - 273.36μg/L). The prevalence of mild iodine deficiency was 44% while that of moderate iodine deficiency was 18%. Thirty-eight percent of the school children had normal iodine status and no child was found to be severely iodine deficient. Household salt samples were found to be non-iodated (12%), insufficiently iodated (58%) and 30% were adequately iodated. For 500 gm, fine salt was sold at US $ 0.14 (TSh. 100.00) while coarse salt was sold at US $ 0.07 (TSh. 50.00). Once bought salt was stored in covered containers (55%), uncovered containers (13%), or folded newspapers (32%). With most foods, salt was added at the beginning of a cooking process (1%), during cooking (80%), at the end of cooking (13%) or at the table (6%).
Conclusion: With 62% of the school children having mild and moderate forms of iodine deficiency, results of the present study demonstrate that iodine deficiency is a public health problem in the District. Consumption of iodated salt and foods rich in iodine is low. Education and communication strategies to different stakeholders need to be strengthened to effectively communicate the message on iodine nutrition. There is a need for renewed efforts to reinforce regular monitoring of iodine content of salt especially in the rural areas where informal re-packing of iodated salt and sale of non-iodated salt are common.

INTRODUCTION

Deficiencies of micronutrients such as vitamin A, iron and iodine have a significant impact on human welfare and economic development of developing countries (1). Iodine deficiency particularly affects pregnant women, foetuses, neonates and children (2). The clinical and sub-clinical manifestations of iodine deficiency are collectively termed as iodine deficiency disorders (IDD). Consequences of IDD include spontaneous abortions, stillbirths, congenital abnormalities, infant and young child deaths, impaired mental and physical development of young children, goitre and endemic cretinism. It also impedes children's learning ability (3). The cumulative consequences in iodine-deficient populations spell diminished performance for the entire economy of affected nations (4).

In the last 50 years, many countries in the America, Oceania and Europe have successfully eliminated IDD, or made substantial progress in their control, largely as a result of salt iodisation and dietary diversification (4). Nevertheless, iodine deficiency continues to be a significant public health problem in many countries. Tanzania is moderately affected by iodine deficiency. Spot surveys conducted between 1980 and 1990 found that total goitre rate (TGR) was 37%; 41% of the population lived in iodine deficient areas; and 30 per 1000 prenatal deaths were due to IDD (4).

Tanzania has been implementing a national IDD control programme through distribution of iodinated capsules to individuals in areas of severe endemicity. Universal iodation of salt has been going on hand in hand with laboratory development and research, capacity building, advocacy and public information on IDD (5). In 1998, Tanzania Food and Nutrition Centre (TFNC) carried out a countrywide evaluation of achievements attained and constraints faced by the national IDD control programme. Although significant reductions in the prevalence of TGR were found in nearly all districts surveyed, there were no significant reductions among the districts found in the southern highlands, namely, Ludewa, Songea and Kyela (5).

Prevalence of TGR in Ludewa district in 1980 was 31%. Iodised oil capsules were distributed in the district in 1990, 1993 and 1996, and the coverage has been in the range of 47% to 62%. In the 1998 survey, TGR was found to be around 29% while the availability of iodated salt at the household level was 70% (5). Despite the fact that IDD has been strongly associated with mountainous areas, little information exists about the availability, price and storage of iodated salt in the goitre-endemic areas of Tanzania. This study assessed iodine status of school children, availability, price, use and storage of iodated salt in Ludewa District, Tanzania.

MATERIALS AND METHODS

Study area: A cross sectional study was conducted in Ludewa district of Iringa region in January 2003. The region lies in the southern highlands of mainland Tanzania, between latitudes 7°05′ and 36°32′ south and longitudes 33°47′ and 36°32′ east. The region has a total population of 1,495,333 inhabitants, with average household size of 4.3 people. The region is divided into seven districts. Ludewa district has a total population of 128,520 inhabitants (6). From the four divisions that constitute the district, Liganga and Mlangali divisions were randomly selected. One ward from each division was randomly selected because of a varied socio-economic status. These included Lugarawa ward (from Liganga division) and Mlangali ward (from Mlangali division), which had 2,510 and 3,209 households, respectively (6). A sampling frame constituting households with school children aged eight to ten years was constructed in each ward. From each ward, a random sample of fifty households with school children aged eight to ten years was selected, making a total of 100 study households.

Subjects: The study population consisted of school children aged eight to ten years and their parents.

Data collection. Primary data were collected using a pre-tested structured questionnaire that sought information on socio-demographic and socio-economic characteristics of the parents; availability, price, use and storage of iodated salt; and cooking practices. Interview was requested from which a pre-tested questionnaire was administered to 100 parents of the school children. Household salt and school children's urine samples were also collected.

Collection of salt samples: A sub-sample of 50 (25 from each ward) households was randomly selected from the main sample of 100 interviewed households. From this sub-sample, household salt samples were collected and were carefully packed in a screw-cap plastic bottle.

Collection of urine samples: From the 50 households that provided salt samples, casual urine samples were obtained from one randomly selected schoolchild aged eight to ten years per household. Fifty children were provided with screw cap plastic bottles and urine samples were collected under supervision of the researchers. Samples were put in ice-packed cool box and transported to the Department of Pathology, Faculty of Veterinary Medicine, Sokoine University of Agriculture, and were stored at -20°C for seven days before analysis.

Analysis of salt samples: Iodometric titration was used to determine the iodine content in salt (7). The method involved the use of sulphuric acid and potassium iodate as principle reagents, standardised sodium thiosulphate (as titrant) and starch solution (as indicator). Using sulphuric acid to liberate iodine from the iodated salt and potassium iodate to solubilise the free iodine, the salt solution was titrated with freshly prepared standardised sodium thiosulphate. The amount of sodium thiosulphate used (usually proportional to the amount of free iodine liberated) was recorded and converted to parts per million (ppm). After analysis, the salt samples were classified according to their iodine levels (8).

Analysis of urine samples: Iodine concentration in urine samples was determined using Sandell–Kolthoff reaction (9) in which urine was digested first with ammonium persulphate. The concentration of iodine was then determined from its catalytic reduction of ceric ammonium sulphate in the presence of arsenious acid. A spectrophotometer (UV-VIS) was used to examine the reduction of ceric ammonium sulphate (yellow). The disappearance of the yellow colour is proportional to the amount of iodine present in the sample. A standard iodine solution was used in order to extrapolate the concentrations of iodine. After determination, the concentration of iodine was recorded in micrograms (μg) of iodine per litre of urine (9) and classified according to IDD status (10).

Statistics: The Statistical Package for Social Sciences (SPSS) software (SPSS–Windows version 9.0; SPSS Inc., Chicago, USA) was used to summarise and analyse the data. Descriptive statistics for all the variables were computed and association between variables were tested using Chi-square test. A value of $P<0.05$ was considered statistically significant.

RESULTS

Background characteristics of the households are presented in Table 1. Majority of the households (81%) were headed by males. Sixty four percent of the household heads had completed primary education and 16% had completed secondary and tertiary education. Mean age of the respondents was 38.10 ± 11.34 years, with minimum and maximum values being 20 and 78 years, respectively. Mean household size was 5.15 ± 1.65 persons, with a range of three to ten persons. The main sources of income for farmers were sale of crops and livestock. Employed workforce depended on their monthly salaries, and these included primary school teachers and community health workers; while those who conducted small business depended mainly on sale of charcoal, local brew, or household wares. The main types of food crops grown were maize, beans and potatoes, and in most cases, these were considered as staple foods. Coffee and wheat were the cash crops grown in the study area. Animal sources of protein, such as beef, sardines, milk and fish, were consumed less frequently by the households due to low income although they were available in local markets.

Table 1

Background characteristics of the households (n = 100)

Characteristic	Proportion (%)
Household headship	
Male–headed	81
Female–headed	19
Sex of respondent	
Male	59
Female	51
Education level of household head	
Never gone to school	8
Not completed primary education	12
Completed primary education	64
Completed secondary education	10
Completed tertiary education[a]	6
Occupation of household heads	
Farmer	74
Small business	9
Formal employment	17

[a] Attained a professional level at a certificate or diploma level

Salt for human consumption was greatly available in the study area and no salt substitute was reported to be used by the households. However, salt samples obtained from the households were found to be non-iodated (12%), insufficiently iodated (58%), and 30% were adequately iodated (Table 2).

Table 2

Iodine content of household salt samples (n = 50)

Iodine content	Number of samples	Proportion (%)
Non-iodated (<5 ppm)	6	12
Insufficiently iodated (5 - 14 ppm)	29	58
Adequately iodated (15 – 45 ppm)	15	30
Over-iodated (>45 ppm)	0	0

Forms of salt used by the households were fine (60%) or coarse (40%). These were purchased mainly in packets (54%) or in uncovered cups (46%). The mean iodine concentration of the household salt samples was 16.62 ± 4.16 ppm for fine salt and 10.02 ± 2.56 ppm for coarse salt (p = 0.044). The price of iodated salt was found to be higher than that of coarse salt. For 500 gm, fine salt was sold at US $ 0.14 (TSh. 100.00) in packets while coarse salt was sold at US$ 0.07 (TSh. 50.00) in uncovered containers. Respondents reported price (35%), taste (31%), packaging (29%) and availability (5%) as the factors that determine their choice of salt.

Once bought, salt was reported to be emptied for storage into plastic containers with lids (53%), plastic containers without lids (13%), in folded newspapers (32%) or in covered pots made of clay (2%). The household's salt condition at the time of survey was found to be dry (65%) or moist (35%). With most foods, salt was reported to be added at the beginning of a cooking process (1%), during cooking (80%), at the end of cooking (13%) and at the table (6%).

Median urinary iodine concentration (UIC) of the school children was 86.76 µg/L with minimum and maximum values of 21.69 µg/L and 273.36 µg/L respectively. Mean UIC was 93.71 ± 48.10 µg. Table 3 presents a classification of children according to IDD status using urinary iodine concentration. No child was found to be severely iodine deficient. Nearly half (44%) of the school children had mild iodine deficiency and 18% had moderate iodine deficiency. Few children (38%) had normal urinary iodine concentration of 100 µg/L or above.

Table 3

Classification of children according to IDD status using urinary iodine concentration (UIC) (n = 50)

Iodine status (UIC)	Frequency	Proportion (%)
Severe deficiency (<20 µg/L)	0	0
Moderate deficiency (20-49 µg/L)	9	18
Mild deficiency (50–99 µg/L)	22	44
Adequate (100–199 µg/L)	17	34
More than adequate (≥200 µg/L)	2	4

DISCUSSION

Generally, the household characteristics observed in this study reflected a typical rural area with agriculture, specifically crop production and animal husbandry, as the main activity for subsistence. There were no significant associations between household characteristics and children's iodine status. Urinary iodine concentration provides a good index of iodine intake and school children have been widely recommended as a representative group when assessing state of iodine deficiency in an area (9, 10). Using WHO urinary iodine concentration as an indicator for degree of severity of IDD (10), the prevalence of IDD in this area was high (62%) and was to a greater extent contributed by children who were mildly iodine deficient.

The low median urinary iodine concentration (86.76 µg/L) found in this study confirms that the area is mildly affected by iodine deficiency. This value is lower than the usually accepted median values of 100 – 200 µg/L (13) and is also lower than 92 µg/L reported in the 1998 survey (5). WHO classifies an area with mild IDD if the median urinary iodine level is between 50 and 99 µg/L (10).

The shift in median UIC towards the lower levels could have been contributed by inadequate dietary intake, inadequate intake of iodine–rich foods and consumption of iodine-depleted salt. Although no quantitative assessment of dietary intake was made, a predominantly cereals– and vegetable–based diet was observed in the area while foods of animal origin, including sea-foods, were less frequently consumed. More than one-third (40%) of the household salt samples were found to be coarse and insufficiently iodated. Low consumption of iodine-rich foods and consumption of inadequately iodated salt, will in the long run contribute to poor iodine nutrition, as evidenced in the prevalence rate of iodine deficiency.

Many years have passed since legislation on iodated salt was enacted as Salt Acts 1994. Four years after the 1998 National IDD control evaluation survey, favourable changes were expected to be observed in this study. These include increase in the proportion of households that used adequately iodated salt and increase in the UIC. The overall proportion of households (76%) using iodated salt in Ludewa in 1998 appears to be higher than the value of 30% observed in this study. The latter value is also lower than that recommended by international organisations, that 90% or more of households should consume iodated salt (10). A similar observation in decrease of proportion of households that consume adequately iodated salt after a great improvement has been reported in Nigeria where more than 95% of the households consumed iodated salt to a level of 50 ppm in the 1994 regional survey compared to the less than 50% that consumed iodated salt to a level of 30 ppm in 1997 (3). It appears that reduced social marketing has a bearing on the decline in the proportion on households consuming iodated salt.

Consumption of insufficiently iodated salt by majority of the households in Ludewa could have been influenced by consumption of coarse rather than fine salt, poor salt handling and storage practices at the retail and household levels, and cooking practices. Coarse salt samples were found to be insufficiently iodated. Most households (87%) purchased their salt from retail shops and nearly half (45%) purchased in uncovered cups. Some retailers usually purchase their salt in bulk bags from salt manufactures, and then sell to small-shop retailers who repackage for final consumers in rural areas and peri-urban communities. Repackaging iodated salt in uncovered cups has been known to allow free contact between salt and air, with the former absorbing air to form moist salt. Any condensed moisture would remain in the salt as a liquid and contribute to instability of iodine (13). Potassium iodate, a fortificant used to iodate salt, has been documented to be reduced to elemental iodine when exposed to heat, light or air. The elemental iodine readily sublimates and is then rapidly lost to the atmosphere by diffusion (13). It was found in this study that once salt is bought for household consumption, it is emptied for storage in uncovered containers or folded newspapers. It was not surprising then that 35% of the salt samples were moist. Moreover, cooking practice in relation to salt iodine retention was poor. Only 19% of the household reported to add salt at the end of cooking and at the table, while 81% added before and during cooking. Long exposure of iodated salt to heat and moisture would accelerate the loss of iodine (13).

Consumption of coarse salt and its storage could also have contributed to the consumption of insufficiently iodated salt. It was found in this study that the mean iodine concentration (10.02 ± 2.56 ppm) of coarse salt fell in the insufficiently iodated (5-14 ppm) category. A study conducted in South Africa documented that the mean iodine content of table salt which is coarse was lower compared to that of fine salt and the losses of iodine from fine salt was lower than those of coarse salt (14). This has been related to the particle size, the iodisation method and the level of impurities in the coarse salt (15). The argument that some salt manufacturers may succeed in producing adequately iodated coarse salt by increasing slightly the amount of iodine (14) may not favour iodine retention in coarse salt given the prevailing handling and storage practices observed in this study. Coarse salt was reported to be sold in uncovered containers in rural markets where it is exposed to heat, light and air.

In general, iodated salt costs more than non-iodated salt because of its additional processing cost. Given a choice, price-sensitive buyers have been reported to be more likely to purchase non-iodated salt if it is cheaper than the iodated product. Usually the low socio-economic sector of a population, which is more vulnerable to iodine deficiency and its consequences, falls into this category (14). As was the case in this study, more than one-third (35%) of the households reported price as the main determining factor when it comes to choice of salt, while 5% cited availability. At the same price, the quantity of coarse salt bought was twice that of fine salt. In the long run, more households might shift to coarse salt as retailers of small shops increase their stock, thus creating difficulties in the implementation of national IDD control programme.

In conclusion, this study clearly indicates that iodine deficiency is still a significant health problem in Ludewa district. More than half of the school children have mild to moderate forms of iodine deficiency. Proportion of households consuming iodated salt is lower than the internationally recommended values for control of IDD. Poor handling and storage practices at the retail and household levels are extensive. For more than one-third of the households, price is the main determining factor when choosing the type of salt to use.

With appropriate legislation on iodated salt in place, all stakeholders need to be involved. Managers of salt manufacturing industry and salt retailers, who operate mostly in a commercial environment, need to have a thorough understanding of the causes, consequences, prevention and control of IDD. This may help to strengthen their commitment as partners towards the implementation of the IDD programme. Regular monitoring by efficient and effective teams of health authorities should be reinforced especially in the rural areas where informal re-packers of salt may operate without government license and sale of non-iodated salt is common. Innovative education and communication strategies, such as social marketing of iodated salt should be employed to effectively convey the iodine message to the general population. Sufficient knowledge about IDD would help to create a demand for iodated salt and increase the consumption of iodine-rich foods.

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