ENVIROMENTAL IMPLICATION OF IODINE IN WATER, MILK AND OTHER FOODS USED IN SAHARAWI REFUGEES CAMPS IN TINDOUF, ALGERIA

Ingrid Barikmo[1], Sigrun Henjum[1], Lisbeth Dahl[2], Arne Oshaug[1], Liv Elin Torheim[4]

[1]Akershus University College, Lillestrøm, Norway, [2]NIFES, Bergen, Norway, [4]Fafo, Oslo, Norway

Abstract

A cross-sectional survey among Saharawi refugees in four camps carried out in 2007, revealed enlarged thyroid volume and high urinary iodine concentration in women and school children. The purpose of this paper is to describe the content of iodine in food and water and explore if any sources in the environment can explain the situation. Samples of water (n=143), milk (n=19) and salt (n=89) were collected. Different wells supplied the camps with water and the median iodine concentration was 108 µg/L (range 55- 545 µg/L) and significantly higher in two of the camps (El Aiune and Ausserd; 300 µg/L (range 55-545µg/L)), compared to the two other camps (Smara; 87 µg/L (55-127µg/L) and Dakla; 70 µg/L (55-96 µg/L)). In local goat milk the median iodine concentration was 370 µg/L (70-13070 µg/L). The median content of iodine in salt was 6µg/g (0-51µg/g). Water and local milk was the most important sources of iodine for women. High levels of iodine in water seem to be one of the main sources of iodine that affects humans as well as animals.

Keywords: excess iodine; water; milk; salt; Sahara desert; refugees

1. Introduction

Goitre is usually a problem of iodine deficiency and it is estimated that 2 billion people worldwide have insufficient iodine intake (de Benoist et al. 2008). A refugee population from Western Sahara living in the Sahara desert south west in Algeria experience the opposite; available data indicate that the population is suffering from goitre because of excess iodine intake (UNHCR/WFP/ICH 2002). A survey conducted in refugee camps in 2007, revealed a high prevalence of enlarged thyroid volume (Tvol) (86 %) and a high urinary iodine concentration (UIC) (median of 565 µg/L) among children (Henjum et al. 2010).

The refugees have been displaced from Western Sahara to the Sahara desert more than thirty years ago, and approximately 161.000 people (personal communication from the Saharawi

Government) are still living in four refugee camps (El Aiune, Ausserd, Smara and Dakla, Figure 1, page 14) in harsh desert conditions in Algeria.

The refugee setting creates problems for their livelihood including their food, nutrition and health situation. They are totally dependent on food aid. The World Food Program (WFP) and United Nations High Commissioner for Refugees (UNHCR) are providing cereals, lentils, sugar, oil and tea. The European Commission's Humanitarian Aid and Civil Protection department (ECHO) and various Non Governmental Organizations (NGOs) are providing pasta, canned fish, barely and maize products, vegetables and fruit.

The purpose of this paper is to describe the content of iodine in food and water and explore if any sources in the environment that can explain the situation of the high Tvol and UIC in this refugee population. These results will be important for developing strategies to reduce the iodine intake among the refugees.

2. Materials and Methods

2.1 Study area

The study area consisted of four refugee camps; El Aiune, Ausserd and Smara are all approximately 25-30 km away from the administrative centre Rabouni, whereas Dakla is another 140 km away (Figure 1, page 14). El Aiune, Ausserd and Samara are located on the Hamada at an altitude of around 350-400 m while Dakla camp is an oasis away from Hamada at about 310 m altitude. The Hamada is a vast desert plain of the Sahara desert consisting of largely barren, hard, rocky plateaus, with very little sand dunes. Summer temperatures in this part of the Hamada, historically known as "The Devil's Garden", are often above 50°C and frequent sand storms disrupt normal life and there is little or no vegetation. Geologically the camps are located in the Paleozoic Basin of Tindouf, which developed multilayered cratonic basin from the period of Cambrian, Ordovician and Devonian. The Paleozoic sedimentation ended at the end of the Carboniferous. After that the Tindouf Basin is in a state of mainly erosive (Traut et al. 1991). All the water sources are wells that are from 80 – 100 m deep.

2.2 Survey design

In January/February 2007 a cross-sectional survey was conducted in the four refugee camps. Iodine concentration was assessed in drinking water (including for tea), salt, milk and other foods collected at household level.

Ninety-two households were randomly selected and visited by two teams who collected samples and data during 3 weeks.

2.3 Sample collection

2.3.1 Water

Each household was asked to give a sample of the drinking water they had used the last 24 hours. Three of the households had more than one water source so the sample numbers was n=95. Most households used a special kind of water for making tea, so-called “sweet water”, and in that case also water used for tea was collected (n=51). The samples were collected in 50 ml plastic tubes. All water samples were kept at 16 ºC until dispatch and analysis.

2.3.2 Salt

Approximately ten grams of the salt used the last 24 hours was collected from households (n=86) and bakeries (n=3) and kept in plastic bags at 16ºC.

2.3.3 Milk and food

Goat (n=16) and camel milk (n=3) was collected from the households where the household members had been drinking milk the last 24 hours. The samples were collected in 50 ml plastic tubes and brought to freezers at the camp hospitals the same day and kept at -18 to -20 ºC until analysis. Other items were also collected because they were suspected to contain iodine: bread stabilizer (utilized by the bakeries), tuna fish and high pasteurised low fat cow milk (Cadida). Since these three products were industrialised and standardized items only one sample of each of were collected for analysis

2.4 Dietary intake

For estimating the iodine intake, a 24 hour recall of all foods and drinks consumed the previous 24 hours was carried out. For the women the quantities consumed were assessed by weighing the estimated amount of the same or a similar type of food/drink as they had consumed on an electronic scale (Soehnle, 5 kg maximum, nearest 1 g). The recipes for the dishes consumed were also collected. The children were only asked about the frequency of the food intake. Children less than 12 year were assisted by their mother or another caretaker when reporting their food and drink intake the last 24 hours.

2.5 Analytical methods

Iodine concentration in water and salt from the households and in urine from the participants was analysed at the Iodine Nutrition Laboratories, Nutritional Intervention Research Unit, Medical Research Council in Cape Town, South Africa.

The method used for water and urine was a modified Sandell-Kolthoff method (Sandell & Kolthoff, 1937). Using a specially designed sealing cassette to prevent loss of vapour and cross-contamination among wells, ammonium persulfate digestion was performed in a microplate in an oven at 110 °C for 60 min. After the digestion the mixture was transferred to a transparent microplate and the Sandell-Kolthoff reaction was performed at 25 °C for 30 minutes, and iodine was measured by a microplate reader at 405 nm (Ohasi et al. 2000). The laboratory participate in an external quality program EQUIP (CDC, Atlanta, USA). Standard Curve Range used was 0-400 µ/L. All samples above 380 µg/L were diluted to obtain a more accurate iodine value.

Salt was analysed by using the standard iodometric titration by sodium thiosulfate (Mannar & Dunn, 1995; De Maeyer et al., 1979; Sullivan et al., 1995). The recovery of iodine in potassium iodate standards in 20 % NaCl was between 97 % and 102 %.

Iodine concentration in the milk, bread stabilizer, tuna fish and the water samples from the wells were determined in duplicates by Inductively Coupled Plasma - Mass Spectrometry (ICP-MS) at the Norwegian National Institute of Nutrition and Seafood Research (NIFES). Samples of milk, bread stabilizer and tuna fish were extracted using tetra methyl ammonium hydroxide (TMAH) as described by Fecher et al. (1998) and Dahl et al. (2003). The water samples were diluted with TMAH prior to analysis. The trueness and the repeatability of the analytical method for iodine were established by analyzing the certified reference material BCR 150 Milk Powder (Community Bureau of Reference, Brussels, Belgium) and the standard reference material NIST 1549 Non-Fat Milk Powder (National institute of Standards and Technology, GaithersburgMD). The average obtained was 1.20 ± 0.05 compared with the certified value of 1.29 ± 0.09 mg/kg and 3.37 ± 0.21 compared with the certified value of 3.38

± 0.02 mg/kg of BCR 150 Milk Powder and of NIST 1549 Non-Fat Milk Powder, respectively. The limit of quantification (LOQ) was defined as ten times the standard deviation of the average iodine concentration in ≥20 blanks. The overall blank was subtracted from the results obtained for the test sample solutions.

2.5 Statistics

Data entry and analyses were done by using SPSS version 16.0 (SPSS Inc, Chicago). All of the variables presented were highly skewed and descriptive statistics were therefore reported as median and range. Continuous variables were compared by the Mann-Whitney U test or Spearman's rank-order correlation. Categorical variables were compared using the chi-square test. Two-tailed tests with a significance level of 5% were used throughout. The iodine intake and food groups were calculated by using the nutrient calculation program Foodcalc (Lauritsen 1998).

3. Results

The sources of iodine are presented in Table 1 (page 13). The median iodine concentration in drinking water was 108 µg/L (range 55-545 µg/L). There were large variations in the median iodine concentration in the drinking water between the camps: about 300 µg/L (range 55-545 µg/L) in El Aiune and Ausserd to 87 µg/L (range 55-127 µg/L) in Smara and 70 µg/L (range 55-96 µg/L) in Dakla. The iodine concentration was significantly higher ($p<0.001$) in El Aiune and Ausserd compared to Smara and Dakla (Figure 2, page15).

The median iodine content in water used for tea was 148 µg/L (range 29-367 µg/L) and 87 % of the women and 26 % of the children reported to had drunk tea the last 24 hours.

The content of iodine was high also in locally produced milk (Table 1). The median iodine content in goat milk samples (n=16) was 370 µg/L (range 70-13070) and in the 3 camel milk samples 540, 4170 and 11980 µg/L respectively. In total 34 % of the women and 23 % of the children reported that they had drunk local milk. The content of iodine in processed milk was 190 µg/L and 4 % and 3 % of the women and children, respectively, had drunk this kind of milk.

Table 1 shows that median iodine content in salt (n=89) was 6 µg/g salt (range 0-51 µg/g). Different types of salt were used in the camps; salt as stones more that 2 cm in diameter (n=40) contained median iodine of 4 µg/g (range 0-16 µg/g), coarse salt (n=13) median 5 µg/g (range 0-30 µg/g) and fine salt (n= 36) had a median of 9 µg/g salt (range 0-53 µg/g). Ninety eight percent of the women reported that they had used salt in the dishes and the children were served the same dishes as the women.

Figure 2 also shows that the iodine concentration in urine from women and children was significant higher in El Aiune and Ausserd compared to Smara and Dakla.

The content of iodine in bread stabilizer and tuna fish was very low, respectively 0.04 and 0.08 µg/g.

The estimation of iodine intake based on the 24-hour recall revealed that the sources of iodine for women were drinking water, tea infusion, local milk, salt and dairy products such as processed milk, yoghurt and cheese. Figure 3 shows, for all women in total, that drinking water (48 %) and local milk (38 %) were the main sources of iodine intake. It further shows that tea infusion, salt and dairy products were not contributing significantly to the iodine intake. Among the 34 % (n=136) of the women that had drunk local milk, local milk was the main source of iodine (65 %) and drinking water contributed only with 28 % (Figure 3).

4. Discussion

The concentration of iodine in the drinking water was high (median for all camps was 108 µg/L); usually the drinking water contain < 15µg iodine/L (SCF 2002). During the last 30 years the water supply to the refugees has came from different sources such as small wells outside their tents or common water supply. In 1998 the iodine content in the common water supply from Rabouni (supplying Smara and Ausserd) and from El Aiune (supplying El Aiune and Ausserd) was analysed to contain 724 and 934 µg/L respectively. This was much higher than in Dakla, where it was 259 µg/L (Pezzino et al. 1998). This might indicate that people in Dakla have had lower iodine load from drinking water than the other refugees all the time. The last ten years all the camps have gotten new water sources; in 2002-2003 El Aiune and Ausserd got water from deep wells (about 100 m); Dakla got a new water source in 2004 and Smara has since 2005 water that is treated by reverse osmosis. In this survey the median iodine content for all the camps was 108 µg/L but for the two camps El Aiune and Ausserd the iodine concentration was still unacceptably high, about median 300 µg/L.

The reverse osmotic plant for water supply to Smara was used and seems to function well. In this survey it was found that the water contained median 87 µg iodine /L when the samples were taken from the households using this water supply. Noteworthy, it was also taken samples directly from the osmotic plant some weeks later; these samples showed iodine concentration of 37µg/L after purifying and 403 µg/L before, which shows that the osmotic plant was working very efficient. This means that people in Smara now has access to acceptable drinking water.

In animals as in humans 80-90 % of iodine intake is excreted via the kidneys in the urine. In lactating animals milk is also a major route of iodine excretion (Preedy et al. 2009). Henjum et al. (2010) showed that median urine iodine concentration (UIC) in children from El Aiune and Ausserd was 882 µg/L (range 261-3594) and in Smara and Dakla the median UIC was 362 µg/L (range 170-1209) and 359 µg/L (range 102-742), respectively. The differences were significantly higher ($p<0.001$) in El Aiune and Ausserd compared to Smara and Dakla (Figure 2) which correspond to the iodine content in the water.

The refugees from in El Aiune and Ausserd face the biggest problems with high iodine levels in the water which seems quite high because the recommended intake of iodine/day is 90 µg for preschool children, 120 µg for schoolchildren, 150 µg for adolescents and adults, and 250 µg for pregnant and lactating women (WHO 1996; 2007). The usual recommended two litre water per day will result in too high iodine intake of this refugee's, in children as well as in adults. The Sahara desert where the refugees are settled is a former area of sea and iodine is reduced to iodide in the surface waters of the oceans. Macroalgae (seaweed) and phytoplankton release iodine-containing organic gases into the sea. The iodine-containing gases cross the sea - air interface and enter the atmosphere where their iodine is released. Iodine is deposited on land or back into the sea by rain. Dead organic matter becomes buried in marine sediments, where it decomposes and releases iodide into the pore waters. Iodine in soil comes from sediments and near-surface brines formed by evaporation of inland bodies of water, often during geologically recent times. It is a general perception that the content of iodine in food and water depend on the iodine content in the adjacent soil (Koutras et al. 1985). Seawater and seafood are known to have adequate iodine content; usually seawater contain 50 µg iodine/L (SCF 2002) and it is assumed here that this has lead to high iodine concentration in the local water. This seems to be the case also for the water used for tea; it came from a source in the Tindouf district. People call it sweet water because compared to the water in the camps this is less salty and it makes the tea taste better. Even though the water used for tea had a rather high iodine concentration (148 µg/L) it did not contribute much to the total iodine intake (Figure 3). The majority of the women were drinking tea, but they reported to drink three small glasses of approximately 30 ml, about three times a day. This gave less than 3 dl per day, thus the water used for tea did not seem to be a major source of excessive iodine.

Through discussions with families in Dakla, it was discovered that some of the animals were given water from old family wells that were not used by humans anymore. This was the case for the goat milk with iodine concentration of >13000 µg iodine /L. However, a family owing camels used water considered fit for humans (iodine concentration 70µg/L), but still the level of iodine in the milk was high (540 µg/L). Even a good water source gave high concentration of iodine in the milk. So in the process of producing milk the iodine seems to be concentrated beyond what is found in water and thus leading to very high levels of iodine in the milk, which aggravate the high concentration of iodine in what humans consumed. In this survey only 34 % of the women and 23 % of the children had drunk local milk the day before, but among those the contribution of iodine from the milk was high (Figure 3). The Saharawi refugees are nomads and traditionally consume a lot of milk. In the camps the availability of milk has been poor and the animals they have, have mainly been given as aid to the population. Henjum et al. (2010) found a positive relation between having animals in the household and the children's thyroid size. Could water with moderate iodine concentration be a major environmental source to iodine in the milk and thus to excess iodine in the diet?

In industrialised countries the most important sources of iodides are dairy products (because of iodine supplement to the fodder and the iodine-containing sterilizers to the milking equipment (SCF 2002)). The processed milk available in the camps contained 190µg/L which is in accordance with the recommendations and the level of Norwegian milk (110 µg/L) (Dahl et al. 2003). However, only a few percent of the refugees reported to had used processed milk in the present study and therefore this was not considered as a source to excess of iodine in the refugee population.

The available salt was procured by the refugees themselves since the distribution of salt (that was fortified) finished in 2006. According to the refugees the salt was from the area but it is unclear if the fine salt was fortified with iodine or not. Algeria, which is the host country, has legislations on iodine fortified salt, manufactured salt is usually fortified. As mentioned there were different types of salt: big stones, extremely coarse to fine coarse, and fine or powder salt. The fine salt could have been fortified (contained up to 53 µg iodine/g salt, see Table 1) but the stone salt could not been fortified. There were 40 samples of real stones, and 5 of them had from 11–16 µg iodine/g salt and only 7 had zero. Sea salt is known to contain up to 1.4 µg iodine/g, so it was surprising to see the level of iodine in some of the salt samples (SCF 2002). The refugees did not report to use much salt so the contribution of salt to the iodine intake was in the present study estimated to be only 7 %.

Other foods such as tuna fish and bread stabilizer had low concentration of iodine and did not contribute substantially.

In the study area it has been revealed a high prevalence of enlarged thyroid volume and high concentration of UIC in women and children (MoH-Saharawi/NCA/AUC 2008); median UIC of 466 µg/L (range 54–3640 µg/L) and 565 µg/L (range 102–3564 µg/L), respectively. Excess of iodine probably caused by high iodine concentration in water has been reported in China (Li et al. (1987); Zhao et al. 2002; 2002). In Hokkaido, Japan, high iodine concentration in urine (median 728 µg/L (range 53-13700µg/L)) because of excessive and longstanding intake of iodine from seaweed has been reported (Suzuki et al. 1965). In a study of Seal et al. (2005) it was suggested that different environmental factors, such as fortified salt, consumption of significant quantities of iodine from other foods given to the refugees or naturally high level of iodine in water could explain the iodine excess. In 2006 Mekimene et al. reported from an Algerian population living in the Sahara desert in Southern Algeria, that high UIC among schoolchildren (6-12 years) (median UIC in one area was 399 µg/L), correlated to high level of iodine in water (122 µg/L). This area in the Sahara desert in Southern Algeria belongs to the same ecological zone as Tindouf. This point to the possibility that they might have the same environmental challenges as the Saharawi refugees; half of the refugee population as well as the animals in the area still have problems with water containing excessive iodine coming from the local environment.

The methods used to explore the iodine sources in the environment are well tested; they include fieldwork and surveys done according to protocol, with randomly selected households. The analytical methods in use were under control with regard to systematic and random error. The statistical analyses were also done according to protocol and there were never any reason not to trust the outcome of the analysis. The results seems therefore to be reliable and not a function of biases in the data.

5. Conclusions

From the presentation and discussion above we conclude that the refugees as well as their animals are affected by the high levels of iodine in the drinking water. Water and milk were the most important contributors of iodine intake in the refugees. The significant positive correlation between the iodine concentration in the water and UIC support the theory that the high prevalence of goitre in the area is caused by excess of iodine intake from water. The iodine content of the water has to be reduces in the benefit of both human and animals. Through purification with reverse osmosis this can be achieved.

Acknowledgments

This study had finical support from the Norwegian Research Counsel, Akershus University College and Norwegian Church Aid. The authors would also like to thank the Saharawi Government and their staff for support and engagement.

References:

Dahl, L., Opsahl, J.A., Meltzer H.M., Julshamn K. (2003). Iodine concentration in Norwegian milk and dairy products. British Journal of Nutrition 90, 679-685.

de Benoist, B., McLean, E., Andersson, M., Rogers, L. (2008). Iodine deficiency in 2007: Global progress since 2003. Food and Nutrition Bulletin, vol. 29, no. 3, The United Nations University.

De Maeyer, E.M., Lowenstein, F.W., Thilly, CH. (1979). The control of endemic goiter. Geneva, World Health Organization.

Fecher, P.A. Goldmann, I., Nagengast, A. (1998). Determination of iodine in food samples by inductive coupled plasma mass spectrometry after alkaline extraction. *Journal of Analytical Atomic Spectrometry 13,* 977-982.

Henjum, S., Barikmo, I., Gjerlaug, A.K., Mohamed-Lehabib, A., Oshaug, A., Strand, T.A., Torheim, L.E. (2010). Endemic goiter and excessive iodine in urine and drinking water among Saharawi refugee children. *Public Health Nutrition April 1:*1-6. [Epub ahead of print]

Koutras, D.A., Matovinovic, J., Vought, R. (1985). The ecology of iodine. In: J.B. Stanbury & B.S. Hetzel (Eds). *Endemic goitre and cretinism, iodine nutrition in health and disease.* 185-95. New York: Wiley Eastern Limited.

Lauritsen, J. (1998). Foodcalc computer program, version 1.3. Available from: http://www.ibt.ku.dk/jesper/FoodCalc/ [Accessed 15 May 2002].

Li, M., Liu, D.R., Qu, C.Y., Zhang, P.Y., Qian, Q.D., Zhang, C.D., Jia, Q.Z., Wang, H.X., Eastman, C.J., Boyages, S.C. (1987). Endemic goitre in central China caused by excessive iodine intake. *Lancet. 2*, 257-9.

Mannar, V., Dunn, J.T. (1995). Salt iodization for the elimination of iodine deficiency. The Netherlands, International Council for Control of Iodine Deficiency Disorders.

Mekimene, L., Azzout, B., Hersberg, S., Valeix, P., Youyou, A.; Amir, Y. (2006). Influence of water's iodine content on schoolchildren living in four locations of southern Algeria. *Electronic Journal of Environmental, Agricultural and Food Chemistry. 5 (6),* 1610-1614.

MoH-Saharawi/NCA/AUC. (2008). Prevalence of goitre and evaluation of food intake among Saharawi refugees in camps in Tindouf, Algeria. *Report* Akershus University College, Norway.

Ohashi, T., Yamaki, M., Pandav, C.S., Karmarkar, M.G., Irie, M. (2000). Simple Microplate Method for Determination of Urinary Iodine. *Clinical Chemistry. 46*, 529-536.

Pezzino, V., Padova, G., Vigneri, R., Turiano, G.M., Compagno, L., Branca, F., Sidi Mustafa. R. (1998). Iodine-independent endemic goiter in Saharawi refugee camps in South Western Algeria. *IDD Newsletter, Volume 14 Number 1 February*.

: Preedy, V.R., Burrow, G.N., Ross Watson, R. (2009). *Comprehensive Handbook of Iodine Nutritional, Biochemical, Pathological and Therapeutic Aspects.* USA: Academic Press.

Sandell, EB., Kolthoff, IM. (1937). Micro determination of iodine by catalytic method. *Mikrochimica Acta 1*, 9-15.

SCF. (2002). Opinion of the Scientific Committee on Food on the tolerable upper intake level of iodine (expressed on 26 September 2002). European Commission. Health and Consumer Protection Directorate General.

Seal, A.J., Creeke, P.I., Gnat, D., Abdalla, F., Mirghani, Z. (2005). Excess dietary iodine intake in long-term African refugees. *Public Health Nutrition. 9(1),* 35–39.

Sullivan, K.H., Houston, R., Gorstein, J., Cervinskas, J. (1995). Monitoring universal salt iodization programmes. Atlanta: Program Against Micronutrient Malnutrition/Micronutrient Initiative/International Council for the Control of Iodine Deficiency Disorders.

Suzuki, H., Higuchi, T., Sawa, K., Ohtaki, S., Horiuchi, Y. (1965). "Endemic coast goitre" in Hokkaido, Japan. *Acta Endocrinol (Copenhagen*). 50, 161-76.

Traut, M.W., Reed, R.J., Bhattacharyya, D.y Van Houten, F.B. (1991). Geology and Hydrocarbon Potential of the Tindouf Basin, Morocco. Energy & Geosciences Institute at University of Utah (formerly Earth Sciences and Resources Institute at the University of South Carolina), *EGI Technical Report I00280*, Salt Lake City. Utah.

UNHCR/WFP/ICH. (2002). Anthropometric and Micronutrient Nutrition Survey, Saharawi Refugee Camps. *Report*.

WHO. (1996). Trace elements in human nutrition and health. World Health Organization, Geneva.

WHO. (2007). Technical consultation for the prevention and control of iodine deficiency in pregnant and lactating women and in children less than two years old. Geneva, World Health Organization, 2007.

Zhao, J., Wang, P., Shang, L., Sullivan, K.M., van der Haar, F., Maberly, G. (2000). Endemic goitre associated with high iodine intake. *American Journal of Public Health. Oct;90(10),* 1633-5.

Zhao, J., Wang, P., Zhang, Q., Wang, H., Hu, X. (2002). Ecology of high iodine intake and endemic goiter in three counties of Jiangsu Province, China. *Chinese Medical Journal. 115(5),* 850-854.

Table and figures:

Table 1 Iodine content of drinks and salt in the Saharawi refugee camps, February 2007

Sources	*n*	*Unit*	*Iodine concentration Median (range)*
Drinking water:			
El Aiune	25	µg/L	299 (231-545)*[1,2]
Ausserd	20	µg/L	301 (55-418)*[3,4]
Smara	24	µg/L	87 (55-127)
Dakla	26	µg/L	70 (55-96)
In total	**95**	µg/L	**108 (55-545)**
Tea water	51	µg/L	148 (29-367)
Local milk:			
Goat	16	µg/L	370 (70-13071)
Camel	3	µg/L	5563 (540-11980)
Salt:			
Stone	40	µg/g	4 (0-16)
Coarse	13	µg/g	5 (0-30)
Fine	36	µg/g	9 (0-53)
In total	**89**	µg/g	**6 (0-51)**

*Significant differences between the camps ($p<0.05$), Mann-Whitney U-test. 1=between El Aiune and Smara, 2= between El Aiune and Dakla, 3=between Ausserd and Smara, 4=between Ausserd and Dakla

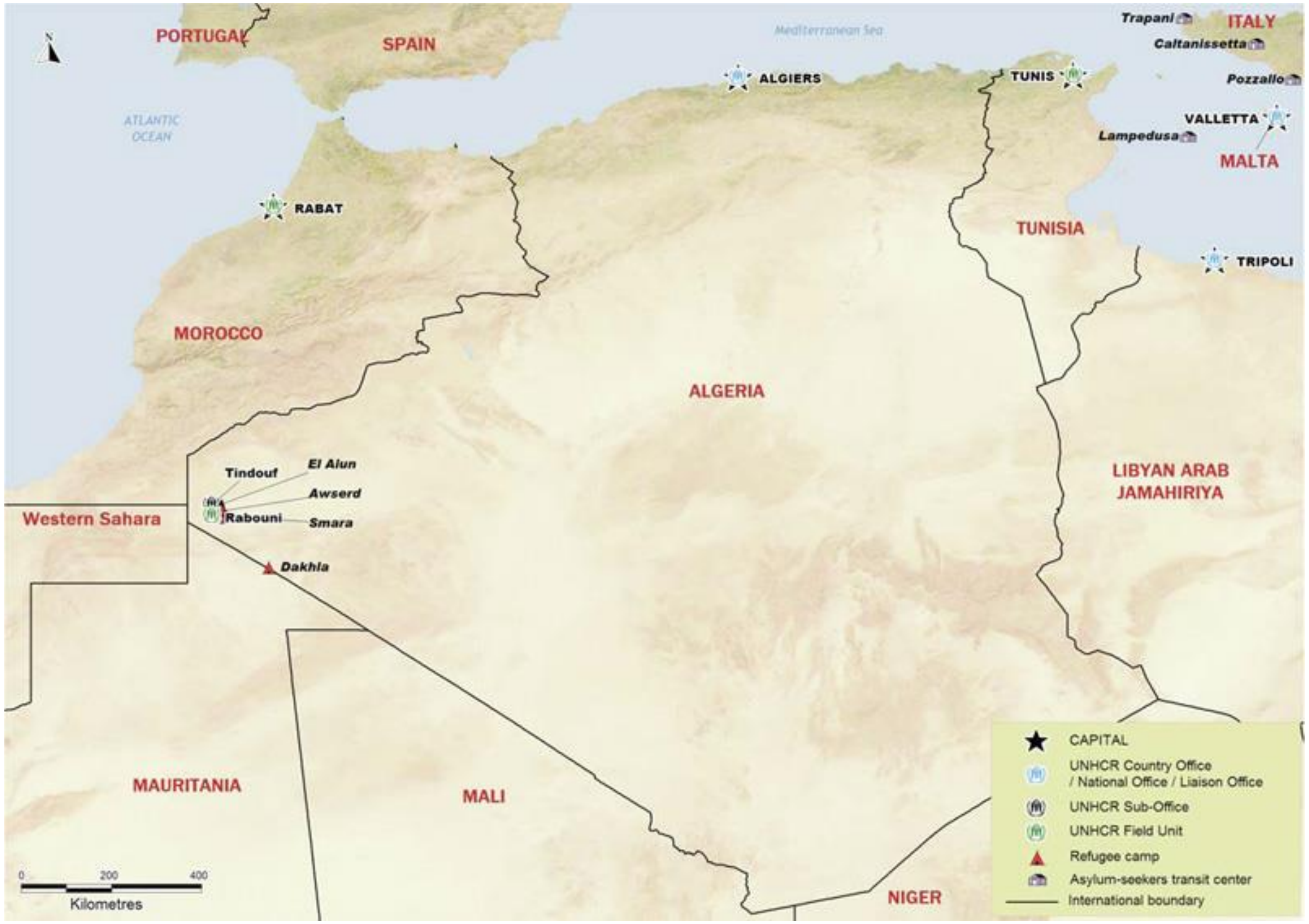

Figure 1 Map showing Tindouf and Rabouni and the four refugee camps, El Aiune, Ausserd, Smara and Dakla

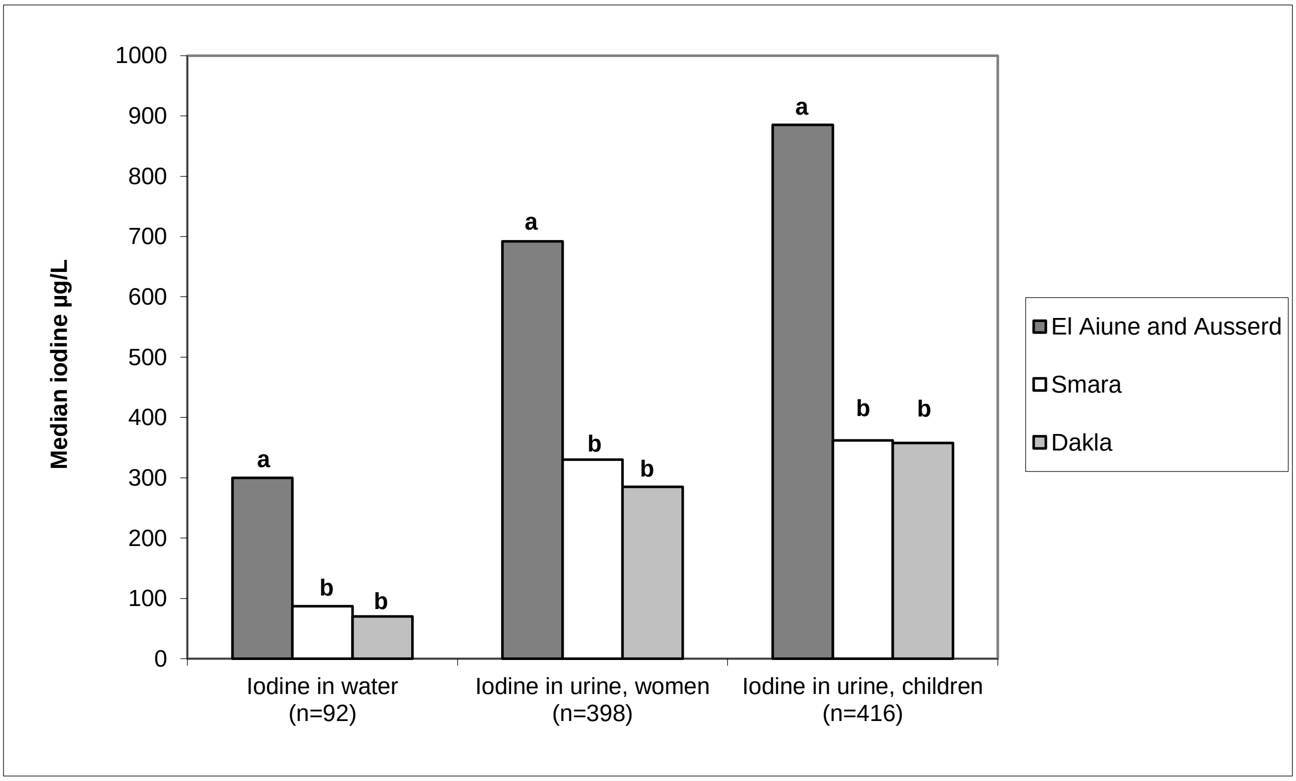

Figure 2 Median µg/L iodine in water and urine from women and children in the different Saharawi refugee camps in the Sahara desert, February 2007
Different letters indicate significant differences ($p<0.05$), Mann-Whitney U-test

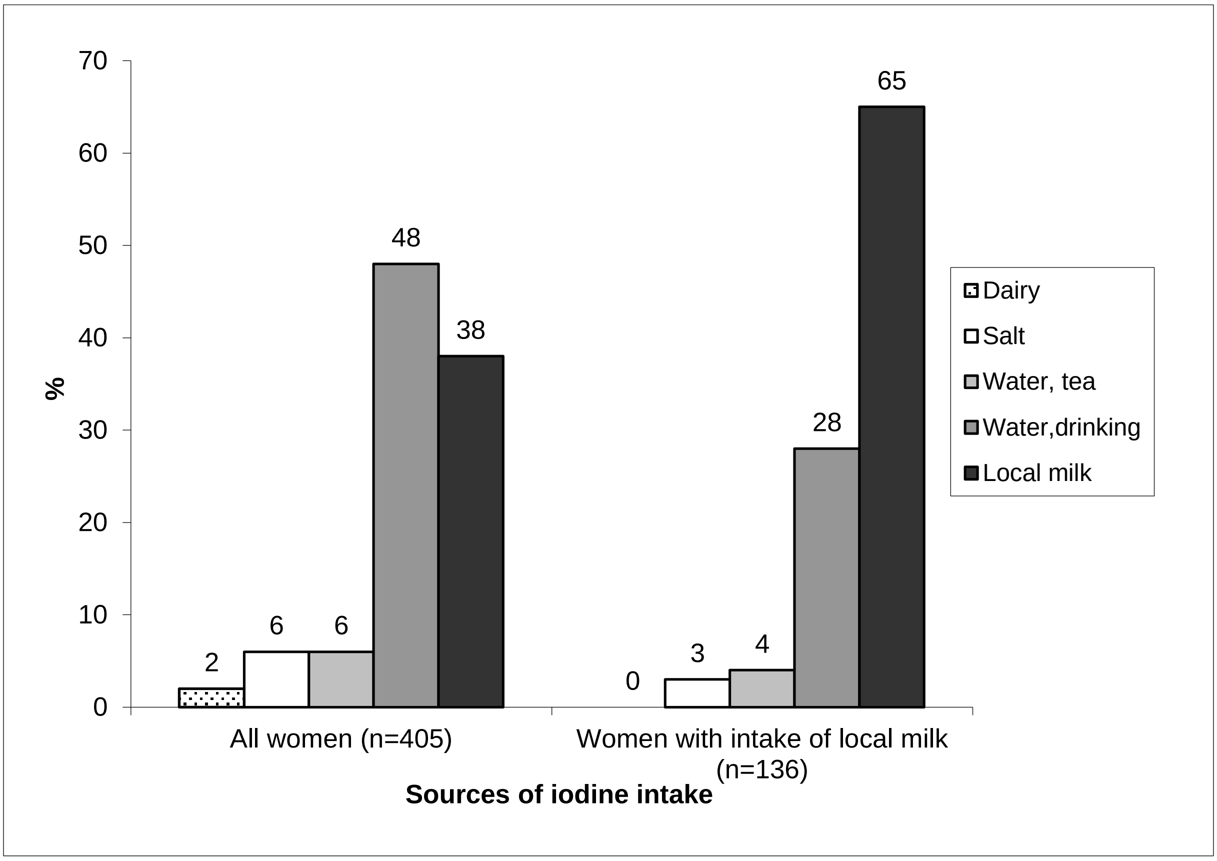

Figure 3 Sources of iodine intake (% contribution) for women in the Saharawi refugee camps, February 2007