

Iodine concentration in household salt in South Africa

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Objective To determine the iodine concentration in household salt, the coverage of adequately iodized salt, the use of non-iodized agricultural and producers' salt, and the usefulness of salt as a carrier of iodine, and to relate these observations to socioeconomic status in South Africa.

Method The iodometric titration method was used to analyse 2043 household salt samples collected using a national, multistage, stratified, cluster survey.

Findings The national mean and median iodine concentrations of household salt were 27 mg/kg (95% confidence interval (CI): 25–29 mg/kg) and 30 mg/kg (range = 0–155 mg/kg), respectively. There was considerable variation within and between geographical areas. Coverage of adequately iodized household salt, i.e. iodized at >15 mg/kg, was 62.4% of households (95% CI: 58.8–66.0%) two years after the introduction of compulsory iodization at a level of 40–60 mg/kg. A total of 7.3% of households used non-iodized agricultural salt and salt obtained directly from producers. People at the lower end of the socioeconomic spectrum were more likely to suffer the consequences of using under-iodized salt because more of them used agricultural or coarse salt than did people in the higher socioeconomic categories. The iodine concentration in salt was lower in rural areas than in urban and periurban areas.

Conclusions The consequences of using under-iodized or non-iodized salt were most likely to be experienced in the country's three northern provinces, among people in the low socioeconomic categories, and in rural households. Since 95.4% of households in South Africa use salt regularly and 2.9% use it occasionally, the national iodization programme has the potential to meet the iodine requirements of the population. However, this can only be achieved if the primary reasons for the inadequate iodization of salt are eliminated and if special attention is given to vulnerable groups.

Keywords Sodium chloride, Dietary/analysis; Iodine/therapeutic use; Households; Socioeconomic factors; Cross-sectional studies; South Africa (*source: MeSH*).

Mots clés Chlorure sodium diététique/analyse; Iode/usage thérapeutique; Ménages; Facteur socioéconomique; Etude section efficace; Afrique du Sud (*source: INSERM*).

Palabras clave Cloruro de sodio dietético/análisis; Yodo/uso terapéutico; Hogares; Factores socioeconómicos; Estudios transversales; Sudáfrica (*fuentes: BIREME*).

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Introduction

Iodine deficiency resulting from inadequate dietary iodine intake is causally related to a spectrum of diseases collectively referred to as iodine deficiency disorders (IDDs). These include preventable conditions such as impaired mental function, goitre, hypothyroidism, cretinism, and retarded physical development; iodine deficiency also causes increased

child mortality (1, 2). Iodization of salt is widely regarded as the most effective and sustainable long-term public health measure for the prevention and control of IDD (3–5).

In an attempt to eliminate iodine deficiency and to comply with the international goal of universal salt iodization, compulsory iodization of all table salt was introduced in South Africa on 1 December 1995. However, salt packaged in bags of 20 kg or more, and used in the manufacturing of compound foodstuffs, was exempted from this requirement. Compulsory iodization replaced optional iodization and increased the iodine concentration of table salt from 10–20 mg/kg to the current level of 40–60 mg/kg at the site of production. Potassium iodate continued to be used as the fortifying agent. Although not attaining the concentration required by law, the introduction of compulsory iodization had a beneficial effect on the

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iodine concentration in salt stocked by retailers in three of the country's nine provinces (6). The mean iodine concentration of such salt rose from 14 mg/kg to 33 mg/kg within a year. Moreover, 74.9% of the salt samples obtained from retailers had an iodine content exceeding 20 mg/kg, while for 89.2% the level was above 10 mg/kg. However, determining the iodine content in salt stocked by retailers could fail to give an accurate reflection of the iodine concentration to which consumers are exposed at the household level. This arises because of potential iodine losses and the use of non-iodized salt obtained from sources other than retail stores. Furthermore, the monitoring of salt stocked by retailers does not yield reliable information on household coverage and the usage of adequately iodized salt, or on the non-use of salt.

There are many salt producers in South Africa, and salt used for agricultural purposes is not iodized. Non-iodized salt for household use can be obtained from agricultural sources, directly from producers, or from other sources. For the efficient prevention and control of iodine deficiency, it is important to quantify the extent to which this happens on the provincial and national scales in order to define subsets of the population that are deprived of iodized salt.

Salt may be lacking in households of low socioeconomic status and in rural areas. For example, in the Lesotho Highlands it was found that 21% of households did not have salt (7). Clearly, the usefulness of salt as a carrier of iodine needs to be assessed by means of household surveys, particularly in developing countries.

Two years after the introduction of compulsory iodization in South Africa at 40–60 mg/kg, we conducted the first national survey of the iodine concentration in salt used in households and report the results in this article. The principal aims were as follows: to determine the national and provincial mean and median iodine concentrations in a representative sample of households; to determine the provincial and national coverage of iodized salt, i.e. the proportion of households using adequately iodized salt; to determine the percentage of households using non-iodized salt of agricultural origin or obtained directly from producers; to determine the proportion of households using salt, as an indicator of the usefulness of salt as an iodine carrier; and to relate these variables to socioeconomic status in order to assess the effectiveness of compulsory iodization in the different socioeconomic strata of the population.

Methods

Sample design

A cross-sectional survey was conducted using a multistage stratified cluster sample of a planned 2200 households, based on the 1991 South African national population census figures. The questionnaire data and the salt samples were collected by an

experienced market research organization as part of a regular household survey conducted by personal interview. For the selection of participants, a proportional sample allocation was made using the 1991 population census figures for different residential categories in each of the nine provinces of South Africa. These residential categories included traditional tribal rural areas, and, in both metropolitan and non-metropolitan areas, informal settlements, hostels, townships, and towns and cities. The only exceptions to proportional allocation arose because: a minimum of 100 households was required per province; and a minimum of 100 Asian households was fixed for the overall sample.

Census enumerator areas ($n = 295$) were drawn with probability proportional to size in the nine provinces of South Africa and the various residential categories. Systematic subsampling in these areas covered either four or eight households with equal probability. By means of a random grid, adult respondents (≥ 18 years of age) were selected for interview from qualifying households.

Data collection

Fieldwork consisted of completing a structured questionnaire and the collection of approximately 15 g salt (three teaspoons) from each household. The minimum requirements for field workers were that they had completed 12 years of education and were bilingual or multilingual, with the ability to speak the local language in the fieldwork areas. Following training of fieldwork coordinators and fieldworkers, the fieldworkers collected the data and the salt samples in the different regions under the supervision of the coordinators during January and February 1998. Up to three visits were made to each household before substitution was made in accordance with a specific procedure whereby houses to the left, right, front, and back of the initial house were successively selected until a qualifying household was located. The overall substitution rate of 5.9% was attributable to refusal by or unavailability of respondents, inability to communicate, and other factors. After a brief introduction, the questionnaire was completed by personal interview in the language of the respondent. Information was obtained on sociodemographic matters, the availability of table salt in households, whether the salt was fine or coarse, whether it was habitually used, and whether it was of agricultural origin or obtained directly from producers. Coarse salt and medium salt were placed in a single category because it was assumed that respondents and fieldworkers would not be able to distinguish them reliably. The fieldwork coordinators checked that all the questionnaires were correctly completed, and they contacted at least 20% of respondents to verify that the correct procedures had been followed during data collection. In this way it was possible to ensure that the correct sampling procedures were employed and that the data collected were accurate and complete.

At the end of each interview the respondent was asked to provide three teaspoons (approximately 15 g) of the salt that had been used the previous day in the preparation of the household's main meal. This sample was taken from the container of salt used for cooking purposes. The sample was transferred to an iodine-free polyethylene bag, which was tightly sealed by means of a plastic zip and placed in a thick paper envelope. All the samples were analysed by the same person using the iodometric titration procedure (8). In our laboratory the coefficients of variation for this method were 0.68 and 1.05 at 20 mg/kg and 60 mg/kg, respectively.

Data analysis

Sample weights were calculated to adjust for the factors described above in "Sample design" and were used in a weighted analysis of the data. The living standard measure (LSM), a composite socio-economic status index on an eight-point scale, was created from the information in the biographical questionnaire on the availability of household appliances (e.g. refrigerator, vacuum cleaner, television) and facilities (e.g. electricity, domestic servant, flush toilet, motor car), the use of financial services (insurance policy, credit card), and whether the respondent lived in a rural hut. The LSM index was then related to the iodine concentration of household salt by applying Spearman's rank correlation. Basic descriptive statistics were calculated, including frequencies, proportions, means, and medians. The χ^2 test was used to compare proportions between subgroups, and the median two-sample test was used to compare the median values of fine and coarse salt.

Results

The 2227 households included in the survey (more than the planned 2200 because of "over sampling")

were proportionally representative of the country's nine provinces (Table 1), and 2072 of these households provided a salt sample (response rate, 93%). A total of 29 samples contained less than 4 g salt, this quantity being insufficient for analysis. Of the respondents that did not provide a salt sample, 51 said they did not use salt, 31 said that their salt supply had run out, and 73 refused to provide a sample. Data on the iodine content of salt were thus obtained for 2043 households, i.e. 91.7% of the households included in the survey; there were 255 samples in the range 4–10 g, which was sufficient for the determination; all the other samples each weighed more than 10 g.

Nationally, the mean iodine concentration of household salt was 27 mg/kg (95% confidence interval (CI): 25–29 mg/kg), ranging from 17 mg/kg (95% CI: 12–22 mg/kg) to 34 mg/kg (95% CI: 29–38 mg/kg) in the different provinces (Table 1). The data in Table 1 show that the median iodine concentration in the provinces ranged from 6 mg/kg to 42 mg/kg, and that the national median was 30 mg/kg. The distribution of the iodine concentration of household salt is illustrated in Fig. 1. In South Africa as a whole, 13.6% of households used salt without any iodine, and 21.1% used salt with iodine concentrations of up to 10 mg/kg. Only 1.8% of households had iodine concentrations exceeding 80 mg/kg; the highest concentration was 155 mg/kg.

Nationally, the coverage of adequately iodized salt (>15 mg/kg) at the household level was 62.4% (95% CI: 58.8–66.0%) (Table 2). However, the coverage of households using such salt varied widely between provinces, ranging from 39% to 77%.

Fine salt was used in 71.2% of households and coarse salt in 14.9%, with both fine and coarse salt being used in 6.1% of households (Table 2). The mean iodine concentration of fine salt was 31 mg/kg (95% CI: 29–33 mg/kg; median: 32 mg/kg), that of coarse

Table 1. Provincial and national sample sizes in the study and mean and median iodine concentrations of household salt, South Africa

	Provincial sample									National sample
	Western Cape	Northern Cape	Eastern Cape	Free State	KwaZulu-Natal	Mpumalanga	Northern	Gauteng	North West	
No. of enumerator areas (clusters)	32	14	38	22	60	20	22	56	31	295
Sample size	241	100	271	153	450	160	173	446	233	2227
Weighted proportional sample size	239	49	308	153	403	203	223	448	201	2227
No. of salt samples collected	235	98	241	151	398	150	164	393	213	2043
Mean iodine concentration (mg/kg)	30 (25–35) ^a	26 (15–37)	34 (29–38)	28 (23–33)	31 (28–35)	19 (12–26)	17 (12–22)	29 (25–33)	22 (16–28)	27 (25–29)
Median iodine concentration (mg/kg)	33; 20, 50 ^b	33; 8, 45	42; 23, 50	33; 8, 48	35; 10, 50	19; 1, 43	6; 1, 31	27; 6, 48	13; 0, 41	30; 4, 47

^a Figures in parentheses are 95% confidence intervals.

^b Figures in italics are the 25th and 75th percentiles.

salt was 20 mg/kg (95% CI: 16–24 mg/kg; median: 16 mg/kg), that of agricultural salt was 5 mg/kg (95% CI: 2–8 mg/kg; median: 1 mg/kg), and that of salt obtained directly from the producers was 2 mg/kg (95% CI: 0.5–4 mg/kg; median: 1 mg/kg). The iodine concentration of coarse salt was significantly lower than that of fine salt (median two-sample test, $P < 0.0001$).

Estimates were made of the proportions of households using agricultural salt and obtaining salt directly from producers, i.e. in both cases, salt with no added iodine. Table 2 shows a large variation in the different provinces using agricultural salt, ranging from none in Western Cape and Northern Cape Provinces to one in five households in Northern Province; the national mean was 6.5% (95% CI: 4.3–8.7%). Nationally, only 0.8% of households obtained salt directly from producers (Table 2). The sum of these two sources of salt that lacked iodine ranged from 0% in Western and Northern Cape Provinces to 25.7% in Northern Province. Nationally, the corresponding figure was 7.3%.

Nationally, there was always salt in 95.4% of households (Table 2) and in 2.9% it was occasionally present. In only 1.5% of households was salt was never available, while householders in the remaining 0.2% of households either didn't know about the availability or did not respond. The prevalence of salt in households was remarkably consistent in all provinces (Table 2), language groups, educational levels, residential categories, and socioeconomic groups, generally exceeding 92% in these strata.

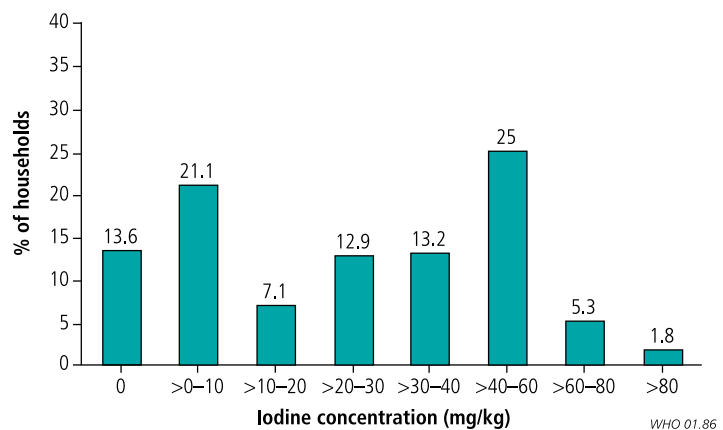
Similar mean iodine concentrations were determined for urban and periurban areas, 32 mg/kg and 31 mg/kg, respectively, but a significantly lower mean value of 23 mg/kg was obtained for rural areas (Table 3).

The relationship between the iodine concentration in household salt and the LSM is illustrated in Fig. 2. There was a weak but significant positive association ($r = 0.17$, $P < 0.0001$) between the iodine concentration of household salt and the LSM. The mean iodine concentration ranged from 5 mg/kg in the households with the lowest LSM values to 40 mg/kg in those with the highest LSM values. Fig. 3 shows that the proportional distribution of the type of salt used varied over the range of LSM values. This gave an indication of the most vulnerable socioeconomic groups using non-iodized or poorly iodized types of salt. In general, coarse or agricultural salt appeared to be used in more households with a low LSM than in ones with a high LSM. Fig. 3 also shows that the proportion of households using fine salt increased with increasing LSM values.

Discussion

The mean iodine concentration of 27 mg/kg in household salt is equivalent to a mean daily iodine intake of 135–270 μg derived from salt, assuming that the daily per capita salt intake was 5–10 g. The

Fig. 1. Distribution of iodine concentration in household salt, South Africa



national median iodine concentration in household salt of 30 mg/kg suggested a slightly higher iodine intake from salt. Despite iodine losses of approximately 20% possibly occurring during the preparation of food (9), the mean and median amounts of iodine derived from salt appeared to be both safe and adequate for the prevention and control of iodine deficiency and endemic goitre (2, 9). However, the national mean and median iodine concentrations masked geographical variations and therefore failed to reveal vulnerable subgroups using under-iodized salt. Geographical variation in the iodine concentration of salt and in the availability of iodized salt appear to be a worldwide problem, as illustrated by the situation in Bolivia, where IDD had been virtually eliminated in 1977 as a public health problem at the national level (10).

The 62.4% coverage of adequately iodized salt, defined in this study as the proportion of households with salt containing more than 15 mg/kg of iodine, falls short of the international requirement of 90% coverage (11). Under-iodization at the production site is a likely explanation for this in South Africa. Interestingly, more than 75% of households in the southern coastal provinces had adequately iodized salt, exceeding 15 mg/kg iodine, in contrast to the country's three most northerly inland provinces where fewer than 50% of households used adequately iodized salt. Iodine losses during transportation, and during retail and household storage, could also have been partly responsible for the inadequate iodine content of salt, particularly in the hot and humid summer climate of the three northern provinces. The household mean iodine concentration of 27 mg/kg was somewhat lower than the mean of 33 mg/kg reported previously for retailer salt (6), suggesting some loss of iodine between the retailer and household. In this connection it is of interest to note that under-iodized and non-iodized salt were reported from Delhi, where 23% of household salt samples contained no iodine despite a ban on the sale of non-iodized salt for human consumption at the time of the Indian study (12).

Table 2. Proportions of study households using different types of salt, South Africa

Type of salt used	Provincial (%)									National (%)
	Western Cape	Northern Cape	Eastern Cape	Free State	KwaZulu-Natal	Mpumalanga	Northern Gauteng	North West		
Any type	92.5	96.8	92.7	96.6	95.0	99.7	94.0	96.1	97.8	95.4 (94.2–96.6) ^a
Adequately iodized, >15 mg/kg	75.8	55.4	77.0	64.7	68.5	45.1	39.0	66.4	48.3	62.4 (58.8–66.0)
Fine	80.3	70.9	52.5	76.0	76.4	69.2	32.8	95.1	65.8	71.2 (67.1–75.3)
Coarse	13.5	26.1	35.9	9.4	5.8	12.7	34.3	2.6	12.2	14.9 (12.0–17.8)
Fine and coarse	4.8	3.0	7.2	5.2	14.4	2.7	5.9	0.9	6.0	6.1 (4.4–7.8)
Agricultural	0	0	4.4	8.9	2.8	12.5	20.5	0.7	15.9	6.5 (4.3–8.7)
Directly from producers	0	0	0	0.5	0	2.6	5.2	0	0	0.8 (0.3–1.3)

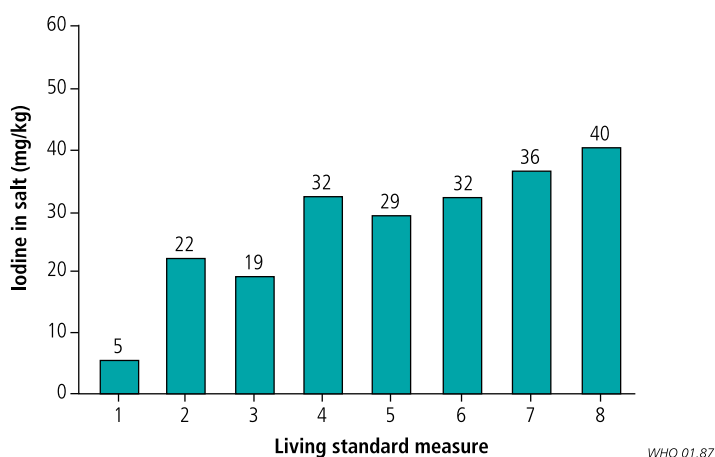
^a Figures in parentheses are 95% confidence intervals.

Table 3. Iodine concentration in household salt in urban, periurban, and rural areas, South Africa

Residential area	Sample size	Mean iodine concentration (mg/kg)
Urban	357	32 (28–36) ^a
Periurban	869	31(28–33)
Rural	816	23 (20–26)

^a Figures in parentheses are 95% confidence intervals.

Fig. 2. Relationship between median iodine concentration of household salt and living standard measure, South Africa



The use of non-iodized salt appeared to be an important reason for the poor coverage of adequately iodized salt in the three northern provinces. Between 15.1% and 25.7% of households in these provinces either used agricultural salt or obtained non-iodized salt directly from producers, the latter practice being absent or virtually absent in some of the other provinces. In South Africa the legal requirement for compulsory iodization of table salt does not apply to agricultural salt, a low-cost product used for animal nutrition and other agricultural purposes. Some

samples of the agricultural salt obtained from households contained low concentrations of iodine, which possibly came from seawater at the production site, from poorly iodized table salt downgraded to or mixed with agricultural salt, or from unknown sources. However, the iodine concentration in these samples was too low to be of benefit. The domestic use of non-iodized agricultural salt could be counteracted by iodizing all agricultural salt. This would also benefit animal production in iodine-deficient areas (1).

The international standard for household coverage of iodized salt has not been met in South Africa, and a substantial subset of the population uses under-iodized salt. Nevertheless, major improvements in salt iodization occurred within two years after the introduction of compulsory iodization at an increased concentration. During the first year the mean iodine concentration in retailer salt increased from 14 mg/kg to 33 mg/kg (6). Meanwhile, the proportion of iodized table salt increased from about 30% before the introduction of compulsory iodization (13) to the current situation where 62.4% of households use table salt with at least 15 mg/kg of iodine. The increases in iodine concentration and in the availability of iodized salt resulted in the elimination of mild-to-severe iodine deficiency, but not of goitre, among schoolchildren of four different communities within a year (14).

The present study showed that salt was always available in 95.4% of households and that in a further 2.9% it was occasionally present. Salt is clearly a very useful carrier of iodine, irrespective of geographical area, educational level, or residential or socio-economic category. The potential thus exists for ensuring the adequate iodine status of virtually the whole population, provided that all household salt is adequately iodized.

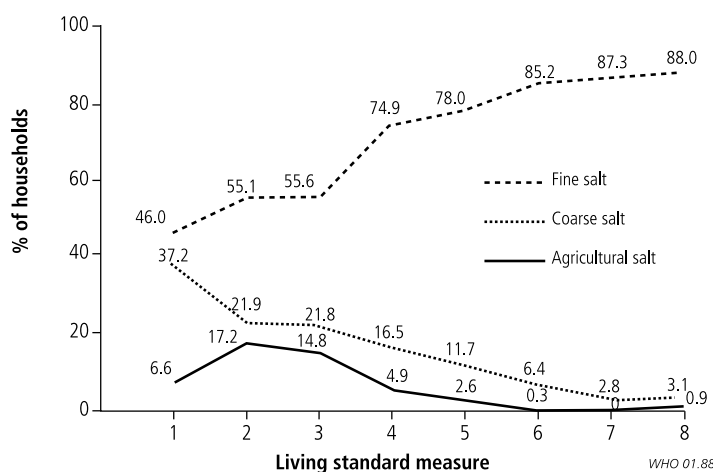
Households in low socioeconomic categories comprised a vulnerable subset of the population at risk of being exposed to under-iodized salt. The situation is further aggravated by the likelihood that people in such households consume less salt than

those in higher socioeconomic groups, thus limiting their potential iodine intake via salt. A partial explanation for the lower level of iodine in the salt used by households in low socioeconomic categories lies in the proportions of the different types of salt used. Agricultural or coarse salt, frequently inadequately iodized or not iodized at all, was used by more households in low socioeconomic categories than by those in higher socioeconomic categories. Furthermore, the proportion of households using fine salt, with its higher mean iodine concentration, was lower in the former socioeconomic categories than in the latter. Compulsory iodization appeared less effective in the low socioeconomic than in the high socioeconomic strata: the indications were that people in the low socioeconomic strata were more susceptible to inadequate iodine intake and, in iodine-deficient areas, to the risk of IDD. Furthermore, the iodine concentration of salt in rural households was lower than that in urban and periurban households. A similar finding was reported from Bolivia (10).

Conclusion

This survey has determined the mean and median iodine concentrations in table salt in South African households to be 27 mg/kg and 30 mg/kg, respectively. Two years after the introduction of compulsory iodization at a higher concentration than before, 62.4% of households were using adequately iodized salt, i.e. > 15 mg/kg of iodine. However, there were considerable variations in the mean and median iodine concentrations of table salt, as well as in the coverage of adequately iodized salt. The most important factors explaining why 37.6% of households were using inadequately iodized salt, i.e. containing < 15 mg/kg iodine, appeared to be the following: under-iodization, domestic use of non-iodized agricultural salt and poorly iodized coarse salt,

Fig. 3. Proportions of households using fine salt, coarse salt, or agricultural salt in relation to living standard measure, South Africa



and direct acquisition of salt from producers. Vulnerability to under-iodized or non-iodized salt appeared to be greatest in the three northern provinces, in households belonging to low socioeconomic categories, and among people living in rural areas. Since 95.4% of households in South Africa use salt regularly, and 2.9% do so occasionally, the national iodization programme has the potential to meet the iodine requirements of the population provided that the primary factors behind inadequately iodized salt be eliminated and that particular attention be paid to vulnerable groups. ■

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Conflicts of interest: none declared.

Résumé

Teneur en iode du sel de table en Afrique du Sud

Objectif Déterminer la concentration d'iode dans le sel de table, la couverture en sel correctement iodé, l'utilisation de sel non iodé (sel à usage agricole et sel directement acheté auprès du producteur), et l'intérêt du sel comme vecteur d'iode, et relier ces observations à la situation socio-économique en Afrique du Sud.

Méthodes La méthode de titrage iodométrique a été utilisée pour analyser 2043 échantillons de sel recueillis dans les ménages lors d'une enquête stratifiée à plusieurs degrés réalisée par sondage en grappes sur l'ensemble du pays.

Résultats La moyenne et la médiane nationales de la teneur en iode du sel de table étaient respectivement de 27 mg/kg (intervalle de confiance (IC) à 95 % : 25-29 mg/kg) et 30 mg/kg (intervalle : 0-155 mg/kg). Il existait des différences considérables d'une région à

l'autre et à l'intérieur d'une même région. La couverture en sel correctement iodé, c'est-à-dire iodé à >15 mg/kg, était de 62,4 % des ménages (IC 95 % : 58,8-66,0 %) deux ans après l'introduction de l'iodation obligatoire du sel à raison de 40-60 mg/kg ; 7,3 % des ménages utilisaient du sel non iodé, qu'il s'agisse de sel à usage agricole ou de sel acheté directement auprès du producteur. Les ménages des catégories socio-économiques les plus défavorisées risquaient davantage de subir les conséquences de l'utilisation de sel pauvre en iode que les ménages plus aisés car un plus grand nombre d'entre eux utilisaient du sel agricole ou du sel brut pour la cuisine et la table. La teneur du sel en iode était plus faible dans les zones rurales que dans les zones urbaines et périurbaines.

Conclusion Les conséquences de l'utilisation de sel insuffisamment ou non iodé risquaient davantage de se faire sentir dans les trois provinces du nord du pays, parmi les ménages défavorisés et dans les zones rurales. Comme 95,4 % des ménages d'Afrique du Sud utilisent régulièrement du sel et 2,9 % occasionnelle-

ment, le programme national d'iodation doit pouvoir répondre aux besoins en iode de la population. Ce but ne peut toutefois être atteint que si les raisons primaires de l'iodation insuffisante du sel sont éliminées et si l'on porte une attention particulière aux groupes vulnérables.

Resumen

Concentración de yodo en la sal doméstica en Sudáfrica

Objetivo Determinar la concentración de yodo en la sal doméstica, la cobertura con sal suficientemente yodada, el consumo de sal agrícola no yodada y de los productores y la utilidad de la sal como vehículo de yodo, y relacionar esas observaciones con el estatus socioeconómico en Sudáfrica.

Métodos Se usó el método de valoración yodométrica para analizar 2043 muestras de sal doméstica reunidas mediante una encuesta nacional, polietápica y estratificada, por conglomerados.

Resultados Las concentraciones de yodo media y mediana en la sal doméstica a nivel nacional fueron de 27 mg/kg (intervalo de confianza (IC) del 95%: 25–29 mg/kg) y 30 mg/kg (intervalo: 0–155 mg/kg), respectivamente. Había una considerable variación dentro de las zonas geográficas y entre ellas. La cobertura de hogares con sal doméstica suficientemente yodada, es decir, con más de 15 mg/kg de yodo, era del 62,4% (IC 95%: 58,8–66,0%) dos años después de la introducción de la yodación obligatoria a un nivel de 40–60 mg/kg. En total un 7,3% de los hogares usaban sal agrícola no yodada y

sal obtenida directamente de los productores. Las personas ubicables en el extremo inferior del espectro socioeconómico tenían más probabilidades de sufrir las consecuencias del consumo de sal subyodada, pues entre ellas el porcentaje que empleaba sal agrícola o gruesa era mayor que entre las personas de categoría socioeconómica superior. La concentración de yodo en la sal era menor en las zonas rurales que en las zonas urbanas y periurbanas.

Conclusión Las consecuencias del consumo de sal subyodada o no yodada tendían a manifestarse más a menudo en las tres provincias septentrionales del país, entre las personas de bajo estatus socioeconómico y en los hogares rurales. Puesto que el 95,4% de los hogares de Sudáfrica usan sal regularmente, y el 2,9% ocasionalmente, el programa de yodación de la sal tiene el potencial necesario para cubrir las necesidades de yodo de la población. No obstante, ello sólo podrá conseguirse eliminando antes las causas principales de la insuficiente yodación de la sal y prestando especial atención a los grupos vulnerables.

References

1. **Hetzel BS.** S.O.S. for a billion — the nature and magnitude of the iodine deficiency disorders. In: Hetzel BS, Pandav CS, eds. *S.O.S. for a billion. The conquest of iodine deficiency disorders*. Delhi, Oxford University Press, 1996: 3–29.
2. **Delange F.** The disorders induced by iodine deficiency. *Thyroid*, 1994, **4**: 107–128.
3. **Bürgi H, Supersaxo Z, Selz B.** Iodine deficiency diseases in Switzerland one hundred years after Theodore Kocher's survey: a historical review with some new goitre prevalence data. *Acta Endocrinologica*, 1990, **123**: 577–590.
4. **Lamberg BA.** Effectiveness of iodized salt in various parts of the world. In: Hall R, Kobberling J, eds. *Thyroid disorders associated with iodine deficiency and excess*. New York, Raven Press, 1985: 81–94.
5. **Mannar VMG.** Control of iodine deficiency disorders by iodination of salt: strategy for developing countries. In: Hetzel BS, Dunn JT, Stanbury JB, eds. *The prevention and control of iodine deficiency disorders*. Amsterdam, Elsevier, 1987: 111–125.
6. **Jooste PL et al.** Impact after one year of compulsory iodisation on the iodine content of table salt at retailer level in South Africa. *International Journal of Food Science and Nutrition*, 1999, **50**: 7–12.
7. **Jooste PL et al.** Nutritional status of rural children in the Lesotho Highlands. *East African Medical Journal*, 1997, **74**: 680–689.
8. **Mannar MGV, Dunn JT.** *Salt iodization for the elimination of iodine deficiency*. International Council for the Control of Iodine Deficiency Disorders, 1995: 107–112. Available at: <http://www.people.virginia.edu/~jtd/iccidd/iodman/iodman.htm>.
9. *Recommended iodine levels in salt and guidelines for monitoring their adequacy and effectiveness*. Geneva, World Health Organization, 1996 (unpublished document WHO/NUT/96.13). Available at http://whqlibdoc.who.int/hq/1996/WHO_NUT_96.pdf.
10. **PAHO/WHO/UNICEF/ICCIDD/PAMM.** Virtual elimination of iodine deficiency disorders in Bolivia. *Pan American Journal of Public Health*, 1997, **2**: 215–219.
11. *Indicators for assessing iodine deficiency disorders and their control through salt iodization*. Geneva, World Health Organization, 1994 (unpublished document WHO/NUT/94.6). Available at: http://whqlibdoc.who.int/hq/1994/WHO_NUT_94.4.pdf.
12. **Sood A et al.** Relevance and importance of universal salt iodization in India. *National Medical Journal of India*, 1997, **10**: 290–293.
13. **Jooste PL, Marks AS, Van Erkom Schurink C.** Factors influencing the availability of iodised salt in South Africa. *South African Journal of Food Science and Nutrition*, 1995, **7**: 49–52.
14. **Jooste PL, Weight MJ, Lombard CJ.** Short-term effectiveness of mandatory iodization of table salt, at an elevated iodine concentration, on the iodine and goitre status of schoolchildren with endemic goitre. *American Journal of Clinical Nutrition*, 2000, **71**: 75–80.