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Monitoring the effect of introducing mandatory iodisation at an elevated iodine concentration on the iodine content of retailer salt after 1, 3 and 5 years in South Africa

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In this study we monitored the short-term, medium-term and long-term effects of introducing mandatory iodisation at an elevated iodine concentration on the iodine content of retailer salt. In 1995 retailer salt samples were purchased in 48 sentinel towns, situated in three of the nine provinces of South Africa, shortly before the introduction of mandatory iodisation at an elevated iodine concentration of 40–60 ppm, and again 1, 3 and 5 years later. The iodine concentrations in these salt samples were determined by means of the iodometric titration method. Within 1 year the mean iodine concentration more than doubled from 14 to 33 ppm, and further increased to 42 ppm over the next 2 years. However, after another 2 years, the mean iodine concentration relapsed to a lower concentration of 33 ppm. The distribution of iodine values followed the same trend and exhibited a sharp increase in the percentage of under-iodised salt samples at 5 years of follow-up. This study showed the favourable short-term and medium-term impact of introducing mandatory iodisation at an elevated iodine concentration on the iodine content of retailer salt, as well as the reality of a relapse in the long term, emphasising the need for regularly monitoring the iodine content of retailer salt.

Introduction

Various public health interventions are implemented in most countries to prevent the grave consequences of iodine deficiency, such as brain damage, hypothyroidism, endemic goitre, reproductive failure and childhood mortality. Salt iodisation is the most successful long-term precaution against these iodine deficiency disorders (Hetzel & Pandav, 1996; Van der Haar, 1997). Regular monitoring of the iodine concentration of salt at the production sites, as well as at the retail and household levels, is considered a key requirement for ensuring the long-term sustainability of national salt iodisation programmes (WHO/UNICEF/ICCIDD, 2001).

Monitoring the iodine content of salt at the different levels of the salt supply chain to the consumer answers different questions and provides information for different public health decisions. For example, monitoring

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the iodine content of salt at the production site provides information on whether or not the iodine concentration in salt complies with the legal requirement in a country. Household surveys may provide information about the iodine concentration in salt to which consumers are exposed, as well as information about the domestic use of non-iodised salt obtained from sources other than retail stores (Jooste *et al*., 2001). While monitoring iodised salt at the retail level does not provide this sort of information, it serves as a readily accessible sampling point suitable for rapid assessment of the availability of iodised salt in a country or community, as well as indicating changes in iodine content over time of commercially available salt, and of the variation of iodine concentration in iodised salt available in the market place (Muture & Wainaina, 1994; Taha *et al*., 1995).

Due to continued iodine deficiency and endemic goitre in South Africa in the early 1990s (Benadé *et al*., 1997; Jooste *et al*., 1997; Kalk *et al*., 1998), mandatory iodisation replaced optional iodisation at the end of 1995, at a higher iodine concentration (40–60 ppm) than before (10–20 ppm). Within 1 year the mean iodine content of retailer salt, obtained in 48 magisterial districts situated in three of the nine provinces of the country, increased from 14 to 33 ppm (Jooste *et al*., 1999). Despite variation in the iodine concentration of retailer salt, and the fact that 25% of the samples contained less than 20 ppm, the overall distribution of values shifted markedly towards higher values, reflecting the salt producers' prompt response to the revised salt regulation.

From a sustainability point of view, it appeared important to investigate whether the favourable short-term impact was maintained or even improved over time. The aim of this follow-up study was therefore to extend the short-term observations after 1 year (Jooste *et al*., 1999) to investigate the impact of introducing mandatory iodisation at an elevated iodine concentration on the iodine content of retailer salt also in the medium term and long term after 3 and 5 years.

Methods

This study was conducted against the background of revised salt legislation in South Africa, substituting voluntary iodisation of table salt at a concentration of 10–20 ppm with mandatory iodisation at a higher concentration of 40–60 ppm, using potassium iodate as fortificant. As study sites altogether 48 towns, situated in three of the nine provinces (Eastern and Western Cape Provinces and Mpumalanga Province) of the country, were included in the study. The largest as well as some of the smaller towns in each of these three provinces were selected for the study. One retailer shop, where a large proportion of the local community made their food purchases, was selected in each of the 48 towns as a sentinel site for obtaining salt samples during this follow-up study.

Both iodised and non-iodised salt were available in these shops before the introduction of mandatory iodisation, but only iodised salt was obtained for the study. Iodised salt samples were purchased from these selected retailer shops during the month before the introduction of mandatory iodisation, in December 1995, and again 1, 3, and 5 years after introducing mandatory iodisation of table salt in the country. Three random 500 g or 1 kg iodised salt samples, in the standard polyethylene packaging, were purchased of each brand available in these retailer shops. When new brand names appeared on the market during the follow-up stages of the study, samples of these were purchased as well.

The packaged salt samples were kept unopened in the sealed plastic bags in a dark thermoneutral environment until analysed. The iodometric titration method was used for the quantitative determination of the iodine concentration in these salt samples (Mannar & Dunn, 1995). In our laboratory the coefficient of variation for this method is 0.68 at 20 ppm and 1.05 at 60 ppm.

To provide an indication of the shift in distribution of iodine values, distribution curves were constructed and the proportion of samples containing less than 20 ppm was calculated for each of the sampling intervals.

The independent t-test was used to test for significant changes in the mean iodine concentration in the salt between successive sampling intervals.

Results

Retailer salt samples were purchased in the same shops in nine towns in the Eastern Cape Province, nine towns in Mpumalanga Province and 30 towns in the Western Cape Province in 1995, 1996, 1998 and 2000 for the analysis of iodine content. The number of samples increased from a total of 187 samples obtained at baseline to 613 samples at the final sampling interval (Table 1), partly due to an increased number of brand names in the market.

The mean iodine concentration in the provinces increased sharply from 1995 to 1996 as a result of the introduction of mandatory iodisation at an elevated iodine concentration, and the overall mean concentration increased significantly ($P < 0.001$) by more than two-fold from 14 to 33 ppm (Table 1). The mean iodine concentration increased ($P = 0.001$) further over the following 2 years from 33 ppm in 1996 to 42 ppm in 1998, but then, in 2000, slipped back by 21.4% to the 1996 value of 33 ppm ($P < 0.001$). A lower mean iodine concentration in 2000 occurred in all three provinces, but most markedly in the Eastern Cape Province where the 43.5% decrease was from 46 ppm in 1998 to 26 ppm in 2000 (Table 1).

Because considerable variation accompanied the mean iodine concentrations, relative distribution curves of salt iodine values were drawn for each of the sampling intervals (Figure 1). The 1995 distribution in this figure reflects the baseline situation that prevailed during the time that voluntary iodisation at a level of 10–20 ppm prevailed in South Africa. The other three distribution curves clearly showed a shift of values towards higher concentrations. The first marked shift of the distribution of retailer iodine values occurred in 1996, followed by a more gradual increase in 1998, towards higher values. However, the 2000 distribution tended to relapse towards lower values. The shift in distributions is further demonstrated by the proportion of values below 20 ppm at each of the sampling intervals, which was 78.6% in 1995, 25.1% in 1996, 19.2% in 1998 and 37.1% in 2000.

The distribution curves in Figure 1 also show a considerable variation in iodine concentrations at the retail level. During the 1998 and 2000 sampling intervals a low percentage of retailer salt samples, 3.5% and 1.8% respectively, contained more than 100 ppm iodine.

Discussion

This study emphasised the benefit of regularly monitoring the iodine content of salt at the retail level by demonstrating, over a 5-year period, an initial favourable response and an eventual faltering response to the introduction of mandatory iodisation at an elevated iodine concentration of table salt. A marked, and significant, increase from a mean of 14 ppm to 33 ppm in the iodine content of retail salt within 1 year, accompanied by a marked shift of the distribution of values, revealed the rapid reaction of the

Table 1. Mean iodine concentration of retailer salt in three South African provinces before (1995) and after (1996–2002) the introduction of mandatory iodisation at an elevated iodine concentration

	*Mean (standard deviation) iodine concentration (ppm)**			
Province	*1995 (n = 187)*	*1996 (n = 287)*	*1998 (n = 484)*	*2000 (n = 613)*
Western Cape	13 (7)	35 (15)	41 (26)	36 (31)
Eastern Cape	10 (11)	35 (21)	46 (52)	26 (17)
Mpumalanga	18 (13)	27 (18)	36 (12)	35 (23)
Overall mean	14 (10)	33 (18)	42 (37)	33 (26)

* ppm, parts per million (equivalent to mg/kg).

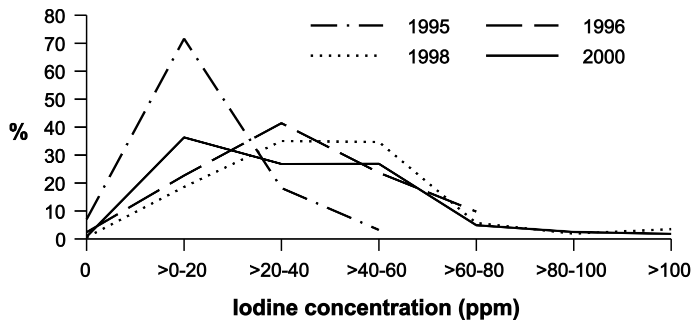

Figure 1. Relative distribution of the iodine content of retailer salt before (1995) and 1 year (1996), 3 years (1998) and 5 years (2000) after the introduction of mandatory iodisation at an elevated iodine concentration.

salt industry to the introduction of mandatory iodisation. Despite the potential loss of iodine between the production site and the retailer shelf (WHO/UNICEF/ICCIDD, 1996), it nevertheless provides important and rapid information to track progress in iodisation programmes.

These changing patterns in the mean iodine concentration over time observed in both the individual provinces as well as in the overall mean, most probably reflected the changes in the effectiveness of iodisation at the production level. In a subsequent assessment of the iodine concentration of salt at all salt producers iodising salt in South Africa, 34.8% of the producers' salt contained less than 20 ppm iodine (Jooste, 2003), in close agreement with the 37.1% of retailer salt samples in three of the nine provinces containing less than 20 ppm in 2000. This close agreement in the estimated percentage of under-iodisation at production and retail levels seems to support the concept that the iodine content of retailer salt reflects the effectiveness of iodisation at the production level.

Elevating the legally required amount of iodine in salt resulted in marked shifts in the distribution of iodine concentration towards higher values during follow-up sampling intervals, as is illustrated in Figure 1. However, these shifts in the distributions were accompanied by increased variation in the iodine values with a substantial proportion of salt samples under-iodised, particularly in 2000. Intervention at production level should therefore aim to increase the accuracy of iodisation and to reduce the variation in iodine concentration. Extreme iodine concentrations at both ends of the distribution should be eliminated first to ensure optimal iodine nutrition in the population and, second, to reduce the potential health risk of iodine-induced hyperthyroidism due to excessive iodine concentrations in salt (Todd *et al*., 1995). Regular monitoring of the iodine content of salt with appropriate follow-up intervention will contribute towards achieving this goal.

The question may well be asked: Why did the mean iodine concentration and distribution of values relapse to lower values in 2000? In view of the well-established salt iodising industry and salt distribution channels in the country, the fundamental cause for the relapse was probably related to the under-iodisation of salt at the production level. This may be an alarm signalling complacency among some salt producers and health authorities failing to conduct sufficient internal and external monitoring as the root cause of the backslide (Dunn, 2000).

In conclusion, this follow-up study demonstrated the remarkable favourable impact of introducing mandatory iodisation at an elevated iodine concentration on the iodine content at the retail level, particularly over the short term and medium term. It also showed the reality of a relapse to lower iodine concentrations in the long term, focusing attention on the possibility of complacency. Overall, the study showed the value of regularly monitoring the iodine content of salt at the retail level for rapid decision-making and appropriate intervention.

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