Iodine deficiency and endemic goitre in the Langkloof area of South Africa

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Objective. To quantify the prevalence of iodine deficiency and endemic goitre in the Langkloof area.

Design. A cross-sectional study.

Setting. Four primary schools in four communities in the Langkloof.

Subjects. 565 primary schoolchildren from Standard 2 to Standard 5.

Outcome measures. Clinical diagnosis of thyroid size by palpation, level of iodine in urine and drinking water samples, level of iodine in iodised salt samples from the area, percentage of households with iodised salt on the premises, and anthropometric measures of body height and weight.

Results. The prevalence of endemic goitre varied from 14.3% to 30.2% in the four communities and, based on urinary iodine levels, the iodine deficiency ranged from mild to severe. Both iodised and non-iodised salt were available at the local grocery stores but only small percentages of households had iodised salt in the house. The iodine content of drinking water was low. Anthropometric indices of undernutrition indicated medium to high levels of stunting in three of the four communities, the worst being in the community with the highest goitre prevalence.

Conclusions. Endemic goitre caused by iodine deficiency is a public health problem in the Langkloof, varying in severity from mild to severe in the different communities. The impact of mandatory iodisation of table salt, introduced at the end of 1995, needs to be assessed in these communities.

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A nutritional deficiency of iodine is a worldwide health problem, which is causally related to a range of abnormalities collectively known as the iodine deficiency disorders (IDD).[1] Examples of IDDs are goitre, hypothyroidism, cretinism, increased perinatal and infant mortality, decreased fertility, retarded physical development and impaired mental function and school performance.[2] In a meta-analysis of studies on iodine and its relationship to cognitive development in 21 diverse cultures, Bleichrodt and Born[3] calculated that iodine-deficient children and adults had a mean IQ score 13.5 points lower than that of iodine-replete groups. Of great public health concern is the indication that these abnormalities occur as a continuum in iodine-deficient communities, rather than as a threshold effect.[4]

In South Africa, information on the question of whether or not iodine deficiency and its biological marker, endemic goitre, prevail is both scanty and outdated. In a recent editorial[5] we made the point that, based on historical data and substantial goitre prevalence rates in neighbouring countries, the strong likelihood exists that iodine deficiency and endemic goitre are an unrecognised public health problem in parts of our country. Historically, in 1927 the medical officer of health, Dr W A Murray, was the first person to report endemic goitre in South Africa when he found goitres in approximately 65% of the inhabitants of the Krakeel area in the Langkloof.[6] Subsequently goitres were found in between 69% and 93% of schoolchildren in this area.[7,8] Endemic goitre has also been found in other parts of the country such as KwaZulu-Natal, the Drakensberg area, North-West, Western Cape, Northern Cape, Mpumalanga and Northern Province.[6] Since Steyn *et al.*'s 1955 report only two further publications have mentioned the existence of goitre in South Africa: in Sekhukuneland, Northern Province, and in Masebuko, KwaZulu-Natal.[9,10] However, urinary iodine excretion as a definitive indicator of iodine status was not measured in either of these studies.

Iodisation of table salt, as a public health measure to prevent iodine deficiency, takes place in most countries of the world. In South Africa legislation allowing optional iodisation of table salt was introduced for the first time in December 1954. However, before mandatory iodisation was introduced through revised legislation in December 1995, only about 30% of table salt was iodised and the distribution depended on consumer and trade demand rather than on health needs.[11] Therefore, it appeared likely that insufficient iodised salt was consumed in the Langkloof area to prevent and control the endemic goitre reported earlier. Not only did it appear likely that insufficient iodine was obtained via the salt route, but an early study by Steyn *et al.*[6] also reported low levels of iodine in the drinking water, which probably worsened the iodine shortage.

Already in 1978 a Medical Research Council Project Group recommended that the prevalence of goitre needed to be reassessed in the so-called prevalent areas.[12] As the Langkloof had been a focal point of endemic goitre in the past, the aim of this study was to investigate the prevalence of iodine deficiency and endemic goitre in primary schoolchildren in four communities in the Langkloof before the introduction of compulsory iodisation of table salt in South Africa.

Methods

A cross-sectional study, focusing on goitre and related variables, was conducted in the primary schools of four

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communities (Haarlem, Louterwater, Krakeel and Joubertina) in the Langkloof. The Langkloof is a valley about 150 km long and is situated between the Langkloof and Kouga mountains, approximately 70 km inland from the coastal towns of George, Knysna and Plettenberg Bay, with the Langkloof mountain range separating the Langkloof from the coastline.

The study population consisted of the children from Standards 2 to 5. The children in Haarlem, Louterwater and Krakeel were mainly coloured children who lived in rural communities mainly comprising labourers serving the fruit industry of the area. Joubertina is a small town whose school is attended predominantly by white children. In the smaller schools of Krakeel and Joubertina all the children in the selected standards were included in the study. A random sample was drawn in the two larger schools (Haarlem and Louterwater) by the selection of every second child from the alphabetical class lists. School attendance rates of primary schoolchildren exceeded 90% according to the headmasters of the different schools.

A clinician palpated the thyroid of each child and categorised the size of the thyroid according to World Health Organisation (WHO), United Nations Children's Fund (UNICEF) and International Council for the Control of Iodine Deficiency Disorders (ICCIDD) criteria[13] as normal (grade 0), palpable but not visible (grade 1) or visible and palpable (grade 2). Anthropometric measurements of body weight (on a calibrated load cell-operated electronic scale with participants dressed in light clothing without shoes) and height (with a staturemeter) were also taken. Teachers assisted in the recording of participants' demographic data such as name, birth date and gender, which were taken from the class register.

A casual urine sample (approximately 20 ml) was collected from each participant between 09:00 and 12:00 and stored below 4°C until analysed. The urine samples were analysed by means of manual acid digestion with spectrophotometric reading of the Sandell-Kolthoff reaction.[14] This method has a coefficient of variation of 4.7% in our hands. Our laboratory also participates in an ongoing international quality control programme for iodine analysis in urine and salt, organised by the Programme Against Micronutrient Malnutrition (PAMM) of the Centers for Disease Control in Atlanta, USA.

Information on some of the important dietary sources of iodine was also obtained by means of a short questionnaire sent to the parents of each participating child, requesting them to indicate whether 'iodised' or just 'table salt' which, in practice, was non-iodised salt, was printed on the container in which their table salt was purchased. A sample from the drinking water supply of each of the communities in the study area was taken and analysed in duplicate for iodine concentration by the same method as that used for urinary iodine. Finally, to complete the iodine picture in the communities, the local grocery stores were visited to establish whether or not iodised salt was available in each of the communities. At least one 500 g packet of iodised salt was purchased in shops that stocked iodised salt and analysed for iodine content via an iodometric titration method.[15]

Written consent was obtained from parents of the children before commencement of the study. Permission to conduct the study was also obtained from the respective headmasters and the Ethics Committee of the Medical Research Council. The data were collected in October 1995, before the introduction of compulsory iodisation of table salt in South Africa.

After obvious errors in the data had been corrected, descriptive statistics and graphical displays were generated. Analysis of variance was used to compare urinary iodine levels between households with and without iodised salt available, adjusting for school as a confounder. Anthropometric indices were produced with Epi-Info 6, and undernutrition was expressed as the proportion of individuals with Z-scores more than two standard deviations below the median of the reference values of the National Center for Health Statistics (NCHS).[16]

Results

A total of 565 children in four primary schools from four communities in the Langkloof area, representing 84.3% of eligible children, participated in the study (Table I). Their mean age was 12.6 (SD 1.9) years. A breakdown of the sample sizes, response rates within schools of children eligible for the study and mean ages of the children are given in Table I.

Table I. Characteristics of the study population

	School				
Characteristic	Haarlem	Louterwater	Krakeel	Joubertina	
Sample (*N*)	155	189	150	71	565
Response rate (%)	92.8	97.9	70	74.7	84.3
Mean age (yrs)	12.7	12.5	12.9	12.1	12.6
(SD)	(1.8)	(1.8)	(2.0)	(1.0)	(1.9)

Anthropometric indicators of the nutritional status of these children are summarised in Table II. Weight for height (wasting) was not calculated because the NCHS tables do not provide for calculating this variable in boys taller than 145 cm and girls taller than 137 cm, or in boys older than 11.5 years and girls older than 10 years. This table shows that the severity of undernutrition, as measured by the indicators of height for age (stunting) and weight for age (underweight), was medium in Haarlem and Louterwater and high in Krakeel when compared with the WHO criteria for assessing the severity of undernutrition in populations.[17] Stunting and underweight rates were particularly low in the Joubertina children, probably indicative of a higher socio-economic status than in the other three communities in this study.

Table II. Prevalence (%) of undernutrition in the Langkloof schoolchildren

	School			
Indicator	Haarlem	Louterwater	Krakeel	Joubertina
Height for age				
Mean (SD)	−1.27 (1.02)	−1.39 (1.04)	−1.6 (1.21)	−0.14 (0.97)
% < −2 SD	22.6	28.4	37.3	1.4
Weight for age				
Mean (SD)	−1.01 (0.89)	−1.07 (0.92)	−1.25 (1.10)	0.21 (1.21)
% < −2 SD	11.0	16.3	22.7	0.0

The total goitre rate, consisting of the sum of goitre grades 1 (palpable) and 2 (visible), among primary schoolchildren was 14.3% in the Joubertina children, 25% in Louterwater, 26.3% in Haarlem and 30.2% in Krakeel (Fig. 1). In terms of the WHO, UNICEF and ICCIDD criteria for assessing the severity of IDD based on the prevalence of goitre in school-age children,[13] the goitre prevalence in Joubertina could be seen as mild, that in Louterwater and Haarlem as moderate, while the prevalence in Krakeel borders on severe. Overall, the goitre prevalence of 25.5% in the Langkloof, adjusted for sampling effect and for response rate, was of moderate severity. These goitres were mostly small, as is evident from the low percentage (1.2%) of grade 2 goitres in all the schools.

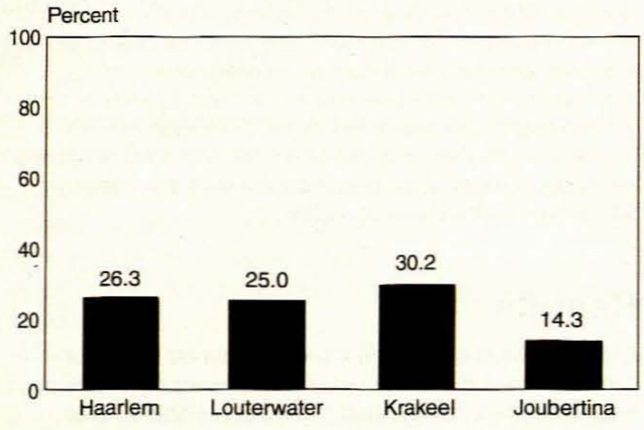

Fig. 1. Prevalence of goitre in the Langkloof schools.

Urinary iodine excretion, considered an important biochemical marker of iodine deficiency, provided further evidence of the general iodine deficiency prevailing in the Langkloof. Fig. 2 shows that the iodine excretion was severely low (< 2 µg/dl) in 39.4%, 55.6% and 76.6% of the primary schoolchildren of Haarlem, Louterwater and Krakeel, respectively. Fewer than 10% of the children in these communities had an adequate (> 10 µg/dl) level of urinary iodine excretion (Fig. 2). Compared with the children in these three communities, only a small percentage (1.5%) of the children in Joubertina had a severely low urinary iodine

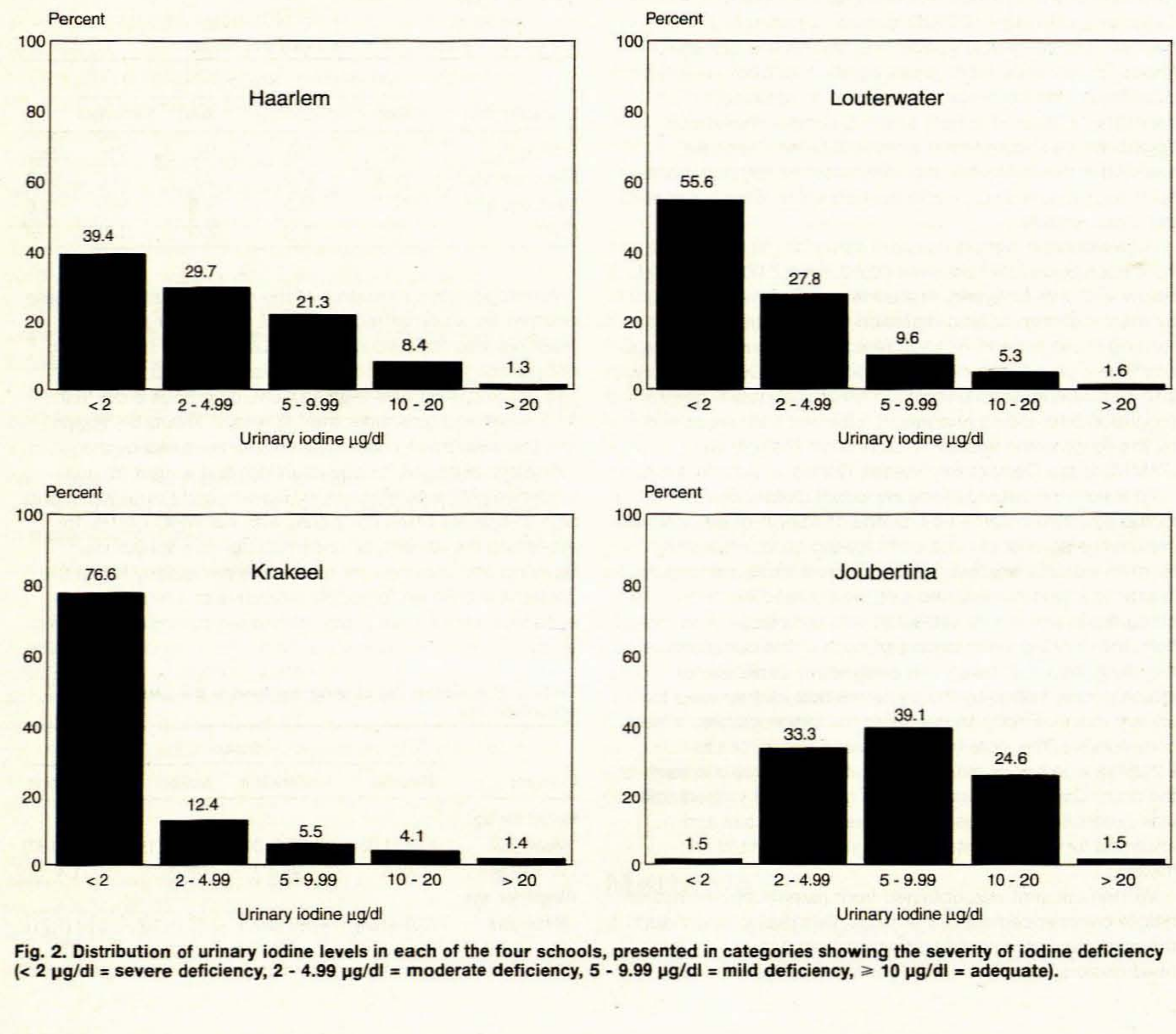

Fig. 2. Distribution of urinary iodine levels in each of the four schools, presented in categories showing the severity of iodine deficiency (< 2 µg/dl = severe deficiency, 2 - 4.99 µg/dl = moderate deficiency, 5 - 9.99 µg/dl = mild deficiency, ⩾ 10 µg/dl = adequate).

excretion (Fig. 2). Also, 26.1% of the Joubertina children had an adequate urinary iodine excretion of more than 10 µg/dl compared with the less than 10% in the other three communities.

The median urinary iodine concentration, another important indicator of iodine deficiency in a population, was 2.7 µg/dl in Haarlem, 1.7 µg/dl in Louterwater, 0.5 µg/dl in Krakeel and 6.4 µg/dl in Joubertina. The overall median urinary iodine level in the Langkloof, with the combined data from the four communities adjusted for sampling effect and response rate, was 2.2 µg/dl. According to WHO, UNICEF and ICCIDD criteria for assessing the severity of IDD, based on median urinary iodine levels,[13] severe iodine deficiency existed in Louterwater and Krakeel where the median urinary iodine levels were below 2 µg/dl. A moderate iodine deficiency existed in Haarlem (median urinary iodine level between 2 µg/dl and 4.9 µg/dl) and the deficiency was mild in Joubertina (median urinary iodine level between 5 µg/dl and 9.9 µg/dl). Therefore, although the urinary iodine levels were generally higher in Joubertina than in the other communities, it is important to note that a mild iodine deficiency was still evident.

Fig. 3 shows the proportion of households using iodised salt. It was low (25% or less) in Haarlem, Louterwater and Krakeel and 45.7% in Joubertina. However, an analysis of variance showed that although urinary iodine levels differed between schools, the availability of iodised salt in the households did not affect the urinary iodine levels. Iodised salt was available in at least one of the grocery stores in each of the communities. The iodine content of the four iodised salt samples purchased in these communities varied from 13.8 to 16.9 ppm, falling in the range specified by the regulation of the Foodstuffs, Cosmetics and Disinfectants Act No. 54 of 1972, before it was revised in December 1995. A sample of drinking water from each of these communities, as another source of dietary iodine, was analysed for iodine concentration. These varied at low levels between 0 µg/dl and 1.3 µg/dl in the four communities; no iodine was detected in the drinking water obtained in Joubertina and Krakeel, and only 0.1 µg/dl and 1.3 µg/dl in that of Louterwater and Haarlem, respectively.

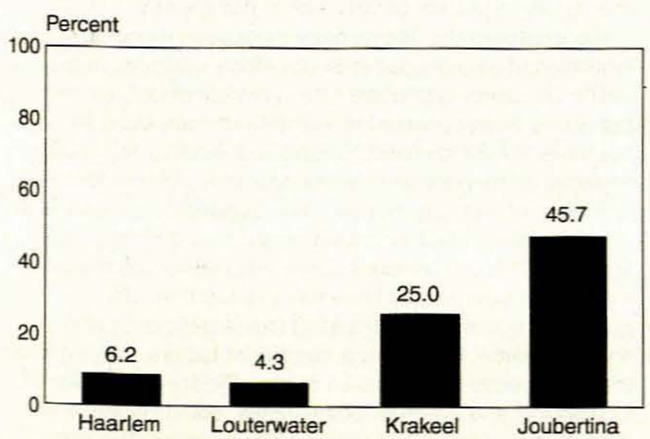

Fig. 3. Percentage of households in each of the communities that had iodised salt in the house.

Discussion

In spite of potentially disastrous effects on physical and mental health, research on iodine deficiency and endemic goitre has been neglected in South Africa for the past four decades. While most other sub-Saharan African countries have estimates of the extent of endemic goitre within their borders,[18,19] we lack reliable data on the prevalence and geographical distribution of endemic goitre and intensity of iodine deficiency in South Africa. As the Langkloof area has been a focal point in local goitre studies since 1927, it appeared to be an important area for reassessment and also to establish whether endemic goitre still prevails in some of the areas where the problem was identified for the first time more than 65 years ago. Added impetus was provided by a district surgeon who had observed abnormal thyroid functioning indicative of hypothyroidism in women in this area.

The prevalence of endemic goitre in the four communities varied from 14.3% in the Joubertina children to 30.2% in the Krakeel children. These estimates should be considered as representative of the situation in the respective communities because of the high response rates of schoolchildren achieved in this study, and the high-school attendance rates reported by the headmasters. Endemic goitre is therefore still a public health problem in the Langkloof varying in severity from mild in Joubertina, to moderate in Haarlem and Louterwater, to severe in Krakeel. Comparison with other geographical areas in South Africa is difficult because of the scarcity of recent estimates of goitre rates elsewhere in the country. In a recent study in KwaZulu-Natal, Benadé and co-workers found goitre prevalence rates of 21.6% in school-aged children in a community survey, and 29.6% in a school survey in the same community, accompanied by low urinary iodine excretion.[20] During the past 2 years endemic goitre was also observed in varying degrees of intensity in parts of Mpumalanga, Gauteng and Northern Province (J Kalk — personal communication, 1996). Two important conclusions could be drawn from this information. The first is that endemic goitre still exists at least in parts of South Africa and, secondly, it appears from the limited data available that marked variation in goitre prevalence rates occurs in the different geographical areas. These deductions emphasise the importance of extending this work to define the distribution and intensity of endemic goitre in the country more accurately.

As was found in a number of European countries,[21] endemic goitre in the Langkloof did not disappear over the years without treatment or adequate public health control measures. The strategy of optional iodisation of table salt, in operation in South Africa since 1954, appeared to be ineffective in eliminating iodine deficiency and endemic goitre in the Langkloof. Optional iodisation, or some other dietary factor or factors, did, however, improve the situation in this area during the past 40 - 65 years because the goitre prevalence rate decreased from excessively high levels (between 69% and 93%)[6-8] to the current level of about 25%. Visible goitres also decreased markedly from levels that varied between 3% and 22% reported by Steyn *et al.*[6] in 1955 to the current low level of 1.2%.

In the absence of urinary iodine measurements, the endemic goitre in the Langkloof was originally assumed to have resulted from an inadequate dietary intake of iodine accompanied by the low phosphorus and high calcium content of the diet.[8] The extremely low urinary iodine excretion measured in this study, particularly of the children in Krakeel, leaves no doubt that iodine deficiency was the primary cause of the endemic goitre observed in this area. Mean goitre rates among the Langkloof communities were generally inversely associated with the median iodine excretion at the population level, as was also observed in Zimbabwe.[22] The mean goitre rate also showed an inverse association with the urinary iodine levels in the study population as a whole. Goitrogens as a possible contributing factor to the aetiology of the endemic goitre in this area were not investigated in this study. It is not impossible that they played some minor role in causing or aggravating the goitres, but in view of the poor iodine status reflected by the low urinary iodine excretion, it is evident that an inadequate iodine intake was the major cause of the goitres.

Differences between communities in goitre rates also broadly reflected the different socio-economic levels encountered in the four Langkloof communities. Although not specifically investigated, it was clear that the socio-economic status of the three communities of Haarlem, Louterwater and Krakeel, where the goitre rates exceeded 25%, was lower than that of Joubertina, where the goitre rate was 14.3%. Thus it would appear that endemic goitre is more likely to occur in low socio-economic communities. A low socio-economic status is generally associated with a high prevalence of retarded growth or stunting, indicating chronic undernutrition. Stunting was highest in Krakeel where the prevalence of goitre was the highest, and contrasted with the situation in Joubertina where the lowest prevalence of stunting was accompanied by the lowest prevalence of goitre. When the data from the four schools were combined, the z-scores of height for age (indicative of stunting) and weight for age (indicative of underweight) correlated negatively with the prevalence of goitre. Therefore, more goitres were found in undernourished children.

It is important to understand that endemic goitre represents a diagnosis relating to the community rather than to the individual. Clinically euthyroid schoolchildren born and living in an iodine-deficient environment could have subclinical hypothyroidism and even subtle deficits of intellectual and motor development.[2,23] For example, in a goitre study on schoolchildren in Caprivi, Namibia, between 22% and 24% of non-goitrous children, living in an endemic goitre area, had abnormal serum thyroid-stimulating hormone and thyroxine levels, indicating subclinical hypothyroidism.[24] The overlapping of mental and physical abnormalities between goitrous and non-goitrous children living in the same environment could result from interobserver variation in the diagnosis of grade 0 and grade 1 goitres[25] or, in severe endemic goitre, from thyroid failure occurring during the fetal or early postnatal period, i.e. during the critical period of brain development.[2]

The low median urinary iodine levels, particularly in Krakeel, reflected a poor dietary intake of this micronutrient in these communities. Despite the availability of iodised salt in the grocery stores of the area, only a small proportion of households (between 4.3% and 25%) in the three communities where iodine deficiency was moderate to severe had iodised salt on the premises. In Joubertina, where a mild deficiency occurred, less than half (45.7%) of households had iodised salt in stock. However, because the analysis of variance showed that the availability of iodised salt in the household did not affect the urinary iodine levels, it is possible that the use of iodised salt was limited to too few households, or the level of iodine in the iodised salt was too low to prevent or control the endemic goitre in the Langkloof. As iodised and non-iodised salt were similarly priced, these data indirectly reveal the low level of awareness of the health benefit of iodised salt among the population in this area. In view of the considerable potential for improvement, it appears reasonable to expect a marked reduction in the iodine deficiency and endemic goitre with the use by all households of salt iodised at higher levels than before. Therefore, the effect of the revised regulation of the Foodstuffs, Cosmetics and Disinfectants Act No. 54 of 1972 with regard to table salt, which introduced mandatory iodisation of table salt at the end of 1995 as a public health measure to prevent and control iodine deficiency and endemic goitre, needs to be evaluated in this area.

Iodine in drinking water is another potential dietary source of iodine. Although the iodine in drinking water usually provides a small percentage, about 10%, of the daily iodine intake, it serves as an indication of the availability of iodine in the environment for incorporation into the food chain. The results of the present study confirmed the earlier findings of Steyn *et al.*[6] in that the iodine content of drinking water in the Langkloof was low, compared with that of non-goitrous areas.[6] It could be speculated that the limited availability of dietary iodine in the Langkloof was partially overcome in the higher socio-economic community by their Western diet, which consisted of a large variety of foods, and the fact that almost half of the households used iodised salt. However, the medium to high stunting rates observed in the other three communities signalled low socio-economic circumstances, usually associated with a more monotonous diet, which in this area was deficient in iodine. Enrichment of drinking water with iodine, as has been done elsewhere,[26] is not recommended in view of the recent introduction of mandatory iodisation of table salt in this country.

It is expected that the recently introduced mandatory iodisation of all table salt in South Africa will improve the iodine deficiency and goitre rate in the Langkloof, as has previously been observed in iodised salt campaigns in countries like Switzerland, Finland and Austria.[2] However, endemic goitre persists in some countries with mandatory iodisation of salt, e.g. Hungary and Yugoslavia, as well as in countries with voluntary iodisation such as Germany, Italy and Spain.[20] It is therefore evident that neither voluntary nor mandatory iodisation of table salt will automatically guarantee success in eradicating iodine deficiency and endemic goitre. Potentially a number of factors, varying from the effectiveness of iodisation to the efficient distribution of iodised salt and eventual iodine intake, could influence the impact of mandatory iodisation in South Africa. The key issue to ensure the success of this public health measure lies in the effective implementation and subsequent monitoring of the iodisation programme and its effects.

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