Mandatory iodisation of table salt at an elevated iodine concentration was introduced in South Africa in 1995 as a public health measure to avoid the grave consequences of iodine deficiency, particularly the effect on brain functioning.1,2 Because mild iodine deficiency was found in children attending a primary school near Worcester in 1998,3 this study assessed the iodine, goitre, and anthropometric indices of nutritional status of Grade 5 and 6 children at the same school 2 years later.

**Subjects and methods**

All the Grade 5 and 6 children, from labourer families, attending the primary school near Worcester in the Western Cape, were included in this study. Written consent was obtained from the parents of the children, the headmaster of the school and the Director of the Boland/Overberg Regional Office of the Department of Health. The Ethics Committee of the Medical Research Council (MRC) approved all the measurements applied in this assessment.

Demographic information regarding birth date and gender was provided by the teaching staff.

Anthropometric measurements of body height and weight were collected for calculation of the indices of nutritional status. Body height was determined to the nearest millimetre using a metal tape fixed to a wall, with a moveable headpiece that was rested horizontally on the head of each child. Body weight was determined without shoes and with the children dressed in light summer clothing, on an electronic scale accurate to 50 g. The z-scores of height-for-age and weight-for-age indices were calculated using the Epi 2000 software programme and the reference values of the National Center for Health Statistics (NCHS).4

The size of the thyroid was determined by palpation as well as by ultrasonography. The thyroid was visually inspected and then palpated and the size categorised according to the joint criteria of the World Health Organisation (WHO), United Nations Children’s Fund (UNICEF) and International Council for the Control of Iodine Deficiency Disorders (ICCIDD) as no palpable goitre (grade 0), palpable but not visible (grade 1) and palpable and visible (grade 2).5 The observer who performed the thyroid palpation (PLJ) was trained by medical colleagues during previous field studies and has gained extensive experience during several studies.
For the ultrasonographic determination of thyroid size, a Toshiba Just Zoom 200 ultrasonograph was used with a 7.5 MHz transducer. Transverse and longitudinal scans were performed of each lobe of the thyroid gland, and the volume of each lobe was calculated using the formula: volume = \(0.479 \times w \times d \times l\), where \(w\) represents the width, \(d\) represents the depth, and \(l\) represents the long axis of each lobe. The thyroid volume was the sum of the volumes of the two lobes. Because undernutrition and retarded growth appeared prevalent among these children, the thyroid size was also assessed in relation to the body surface area (BSA) of the children. The BSA of each child was calculated using the formula: \(\text{BSA} = \sqrt{\frac{71.84 \times w \times d \times l}{71.84 \times 19^4}}\), where \(w\) is the weight in kg and \(H\) is the height in cm. One observer (PLJ) performed both the palpation and the ultrasound measurements on all the children.

The thyroid size of each child, measured by ultrasonography, was then evaluated against the 97th percentile revised cut-off values of the WHO, UNICEF and the ICCIDD for age as well as for body surface area. Children with thyroid sizes exceeding these cut-off levels were considered goitrous. When the prevalence of goitrous, determined either by palpation or by ultrasonography, exceeds 5%, it is said that a public health problem of endemic goitre exists in such a population.

Urine samples were obtained from all the children during school hours, and four drinking water samples were taken from the water tap at the school. The iodine concentration in the urine and water samples was analysed by means of a mild perchloric acid digestion, followed by the spectrophotometric analysis for iodine concentration using the Sandell-Kalthoff method. The median urinary iodine concentration is used to assess the iodine status. A median urinary iodine concentration below 20 \(\mu g/l\) indicates severe iodine deficiency, 20 - 49 \(\mu g/l\) indicates moderate iodine deficiency, 50 - 99 \(\mu g/l\) mild iodine deficiency, 100 - 199 \(\mu g/l\) an adequate iodine intake, 200 - 299 \(\mu g/l\) more than adequate iodine intake, and more than 300 \(\mu g/l\) an excessive iodine intake. The concentration of iodine in 15 retailer salt samples purchased from five small grocer shops in the area, where people from the study area usually buy their food, ranged from 5 to 116 parts per million (ppm), with a mean value of 42 ppm. However, 5 of the 15 samples had iodine concentrations of less than 15 ppm. The mean iodine concentration of household salt samples was also 42 ppm (Table II), ranging from 0 to 184 ppm. However, only 67% of these salt samples were adequately iodised, containing more than 15 ppm of iodine. Four water samples obtained from the water source at the school generally contained little iodine, ranging from 0 to 16 \(\mu g/l\).

### Results

All 66 children in Grades 5 and 6, 42 boys and 24 girls, participated in the study. Their demographic and anthropometric characteristics are summarised, by sex and for the total group, in Table I. This table shows that a substantial percentage of the children were growth retarded as is evident from the high percentage of stunted children (33.3%). Approximately 20% of the children were also underweight. The boys, whose mean age of 13.2 years was higher than the 11.8 years of the girls, had higher stunting and underweight rates than the girls.

The results of the median urinary iodine, prevalence of goitre by palpation, thyroid volume and the iodine concentration in the salt samples brought from home are summarised in Table II. The goitre prevalence (by palpation) in the whole group was 7.6%, accompanied by a median urinary iodine concentration of 177.5 \(\mu g/l\). The median thyroid volume of 2.8 ml was also low, but 2 children were goitrous, representing a goitre rate of 3% based on the ultrasonographic measurement.

### Discussion

Based on the mean iodine concentration of 42 ppm in both the retail and household salt samples, which was higher than in other South African studies, it was reasonable to expect an adequate iodine status in the schoolchildren who participated in this study. Their median urinary iodine value of 177 \(\mu g/l\) indeed indicated a sufficient iodine intake, and was markedly higher than the median value of 97 \(\mu g/l\) obtained in the same school during the national survey more than 2 years earlier.

Although we were concerned about the variability of the iodine concentration in the retail and household salt, and in particular about the third of these salt samples that

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**Table I.** Demographic and anthropometric characteristics (mean ± SD) of the children

<table>
<thead>
<tr>
<th>Study subjects</th>
<th>Mean age (years)</th>
<th>Height (m)</th>
<th>Height-for-age (z-score)</th>
<th>Stunting % &lt; -2 SD</th>
<th>Weight (kg)</th>
<th>Weight-for-age (z-score)</th>
<th>Underweight % &lt; -2 SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>13.2</td>
<td>146.8</td>
<td>-1.44</td>
<td>35.7</td>
<td>37.2</td>
<td>-1.36</td>
<td>21.4</td>
</tr>
<tr>
<td>(N = 42)</td>
<td>± 1.2</td>
<td>± 8.8</td>
<td>± 1.02</td>
<td>± 7.8</td>
<td>± 0.99</td>
<td>± 1.48</td>
<td>16.7</td>
</tr>
<tr>
<td>Girls</td>
<td>11.8</td>
<td>138.9</td>
<td>-1.48</td>
<td>29.2</td>
<td>31.8</td>
<td>-1.48</td>
<td>16.7</td>
</tr>
<tr>
<td>(N = 24)</td>
<td>± 0.9</td>
<td>± 8.3</td>
<td>± 0.95</td>
<td>± 7.1</td>
<td>± 0.95</td>
<td>± 1.33</td>
<td>19.7</td>
</tr>
<tr>
<td>Total</td>
<td>12.7</td>
<td>143.9</td>
<td>-1.45</td>
<td>33.3</td>
<td>35.2</td>
<td>-1.33</td>
<td>19.7</td>
</tr>
<tr>
<td>(N = 66)</td>
<td>± 1.3</td>
<td>± 9.4</td>
<td>± 0.98</td>
<td>± 7.9</td>
<td>± 0.92</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SD = standard deviation.
were under-iodised, the median of the urinary iodine concentration nevertheless indicated a sufficient iodine status in this study population.

An improvement of this magnitude is almost certainly due to a higher iodine intake, and the most likely source of the additional iodine is iodised salt. During the National IDD Survey in 1998, the two salt samples obtained from children of this primary school contained 12 and 17 ppm of iodine, indicating a low iodine content in the salt. Although the sample size was very small, it nevertheless appears likely that the iodine content of table salt increased substantially from the time of the national survey to the time of the MRC assessment 2 years later, providing the additional dietary iodine. The improved iodine status of the children could also be ascribed partly to input from the Department of Health, which ensured that after the 1998 study, children, teachers, parents and shopkeepers in the community in which the school was situated were educated about the importance of using iodised salt; the importance of including foods high in iodine content in the daily diet was also emphasised. Therefore, the information on the iodine status of the children, substantiated by the data on the iodine content of retailer and household salt, indicates an adequate iodine intake in these children and consequently no need for an iodine intervention programme.

Effective salt iodisation results in a rapid eradication of iodine deficiency within 1 year, but the goitre rate among the boys in this school was still one of the highest in South Africa at 23.7% (95% CI: 20.0 to 27.6) years later, providing the additional dietary iodine. The improved iodine status of these children can be ascribed to the national salt iodisation programme providing sufficient iodine to the children, as well as to the nutrition education given to the community.

In conclusion, this investigation showed that the iodine status of the children is currently normal. Although their goitre rate, established by palpation, is marginally above the cut-off level of 5%, the ultrasonographic measurement of thyroid size indicated an acceptably low prevalence of goitre. The improved iodine status of these children can be ascribed to the national salt iodisation programme providing sufficient iodine to the children, as well as to the nutrition education given to the community.

We would like to thank the headmaster, staff and children of the primary school for their wholehearted collaboration in this study.

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Table II. The iodine concentration in urine and salt, and the goitre prevalence and thyroid volume of the study participants

<table>
<thead>
<tr>
<th>Study subjects</th>
<th>Median urinary iodine (µg/l)</th>
<th>Goitre prevalence by palpation (%)</th>
<th>Thyroid volume (by ultrasonography)</th>
<th>Mean iodine content in household salt (ppm) (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys (N = 42)</td>
<td>147.3</td>
<td>9.5</td>
<td>2.8</td>
<td>43 (37)</td>
</tr>
<tr>
<td>Girls (N = 24)</td>
<td>239.6</td>
<td>4.2</td>
<td>2.7</td>
<td>41 (44)</td>
</tr>
<tr>
<td>Total (N = 66)</td>
<td>177.5</td>
<td>7.6</td>
<td>2.8</td>
<td>42 (40)</td>
</tr>
</tbody>
</table>

*Percentage of children exceeding the 97th percentile cut-off levels of the WHO/UNICEF/ICCIDD. SD = standard deviation.

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