A DISSERTATION SUBMITTED IN PART FULFILLMENT
FOR THE DEGREE OF MASTER OF MEDICINE (PAEDIATRICS)
IN THE UNIVERSITY OF NAIROBI.

BY

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*****1989*****
A PREVALENCE STUDY OF IODINE DEFICIENCY DISORDERS
(IDD) IN SCHOOL CHILDREN AGED 6 - 16 YEARS IN
NGINYANG AND MARIGAT DIVISIONS OF BARINGO DISTRICT.
DECLARATION

This dissertation is my original work and has not been presented for a degree in any other University.

Signed:

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This dissertation has been submitted for marking with our approval.

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<tr>
<td>IDD</td>
<td>Iodine Deficiency Disorders</td>
</tr>
<tr>
<td>TSH</td>
<td>Thyroid Stimulating Hormone</td>
</tr>
<tr>
<td>BM</td>
<td>Breast Milk</td>
</tr>
<tr>
<td>TGR</td>
<td>Total Goitre Rates</td>
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<tr>
<td>VGR</td>
<td>Visible Goitre Rates</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organisation</td>
</tr>
<tr>
<td>MIT</td>
<td>Mono Ido Thyrosine</td>
</tr>
<tr>
<td>DIT</td>
<td>Di Ido Thyrosine</td>
</tr>
<tr>
<td>T₃</td>
<td>Tri Ido Thyronine</td>
</tr>
<tr>
<td>T₄</td>
<td>Thyroxine (Tetraiodothyronine)</td>
</tr>
<tr>
<td>CSD</td>
<td>Child Survival and Development</td>
</tr>
<tr>
<td>RIA</td>
<td>Radio Immuno Assay</td>
</tr>
<tr>
<td>IMR</td>
<td>Infant Mortality Rate</td>
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<tr>
<td>PMR</td>
<td>Perinatal Mortality Rate</td>
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<tr>
<td>TG</td>
<td>Thyroid Gland</td>
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Figure 4  - Distribution of goitre by sex and goitre grade.
DEDICATION

Dedicated to my parents, Nyaboke and Keengwe, my wife Nyamoita, and my children Ondicho and Kwamboka.

***************
A random survey of Iodine deficiency disorders (IDD) amongst primary school children was done in 2 Administrative divisions of Baringo district in May, 1988. This was done in order to assess the magnitude of IDD in this district where a multidisciplinary approach in solving problems affecting child survival and development had just been launched. All children in 8 randomly selected schools in these two divisions were examined clinically for goitres and for the presence of signs of hypothyroidism and/or cretinism. 200 children were randomly selected from among these children and their thyroid hormones ($T_3$, $T_4$ and TSH) levels determined. The results of this survey were analysed for age; sex, and place of residence (highland or lowland). Goitre prevalence was more common in females than in males and more in Lowland areas than in highland areas ($p < 0.05$). In school children exposed to Iodine deficiency, hypothyroidism as detected by TSH levels of more than 5 microgramme International Unit/ml was more prevalent than goitre rates. There was no relationship established between TSH levels and goitres, and $T_4$ levels and goitres.
The term Iodine Deficiency Disorders (IDD) was suggested by Hetsel B.S(1) 1983 and includes all aspects of iodine deficiency. It differs from hypothyroidism, a condition of reduced thyroid hormone ($T_3$ & $T_4$) levels in serum, which is only a part of the whole spectra.

Environmental iodine deficiency is the main cause of endemic goitre and hypothyroidism. Naturally occurring goitrogens may play an additional role in the aetiology of endemic goitre. A striking example in Africa is the fascinating study of Delange on Idjwi Island in Lake Kivu, Republic of Zaire (2) where similarly low values of urinary iodine excretion (less than 20 microgrammes/day) coincided with a high goitre prevalence and cretinism in the northern part and a very low goitre rate and no cretinism in the southern half of the island, suggesting that other goitrogenic forces were involved. Yet there is no goitre endemic area in the world, including Idjwi, where a correction of the iodine deficiency was not followed by an often dramatic fall in the goitre prevalence.

Iodine is an essential component of the thyroid hormone, thyroxine, and exist in plasma in two forms.

(i) Free plasma inorganic iodine (P.I.I.) derived largely from dietary iodine and
also from recirculation of iodine.

(ii) Organic iodine (thyroid hormone) bound to proteins (P.B.I).

Circulating Inorganic iodine is trapped by the thyroid gland and eventually incorporated into thyroxine through a series of enzymatically assisted steps. Any factor interfering with the utilization of iodine (Iodine deficiency, goitrogens, and inherited enzyme deficiencies) may produce a fall in level of the circulating thyroxine (the PBI).

Subsequently, anterior pituitary stimulation with release of thyrotrophin, TSH, increases the capacity of the thyroid to trap and handle iodine. This process may be accompanied by an increase in volume of the gland, goitre(3).

The importance of iodine deficiency in a community lies in the disturbance of normal hormone synthesis, rather than in the presence of goitres. The effects of iodine deficiency depends on the age of onset, duration of deficiency; age at diagnosis, and treatment of the deficiency. During fetal life it causes abortions, stillbirths, congenital anomalies, increased perinatal mortality, increased infant
mortality and cretinism. Cretinism is characterised by mental deficiency, deafmutism, spastic diplegia, squints, dwarfism and psychomotor defects (4). In the neonate the symptoms and signs of hypothyroidism are non-specific and include constipation, lethargy, prolonged physiological jaundice, poor feeding, hypotonia, enlarged posterior fontanelle, hoarse voice or cry, enlarged tongue, and umbilical hernia. These symptoms may be present only in 20 to 60% of all hypothyroid infants (5). Only about 5% of all hypothyroid infants detected by laboratory screening programmes are suspected clinically prior to detection (5).

The use of the clinical laboratory is therefore of great importance in the diagnosis of hypothyroidism (5). Hypothyroidism, with early diagnosis and proper treatment, is a preventable cause of irreversible mental retardation. Control of hypothyroidism may lead to an improved quality of life and productivity. The learning abilities of children and adults may also improve with adequate control measures of this preventable malady.

There are several means of assessing the iodine nutrition of populations and individuals and these include :-
(i) **Examination of TG for goitre:**—most common and simple. Problems include inter- and intra-observer consistency.

(ii) **Measuring dietary iodine intake:**
Is difficult. There is also variability of iodine content in foods in different areas hence samples of all foods consumed over a given period will need to be tested.

(iii) **24 hourly urinary iodine excretion:**
Is simple measurement. The main problem with this measurement is that it is difficult to collect a 24hr urine sample in the field. To solve this problem researchers take single urine samples and relate iodine level to the amount of creatinine in the sample. This method is far from being perfect but is believed to be sufficiently accurate for the purpose of community diagnosis when applied to samples of 50 or more individuals (6).

(iv) **Lab procedures to assess T₃, T₄, TSH levels in blood:**
During iodine deficiency serum T₄ levels decrease while TSH increase. T₃ may be normal or increased in moderate deficiency or maybe decreased in severe deficiency.
(v) Measuring the thyroid's uptake of radioactively labelled iodine.

The last procedure requires special equipment and training. It is only appropriate for specialised survey work and is not currently used in ongoing programs for surveillance or evaluation and hence the researcher does not intend to use it.

More than 800 million people in Asia, Africa and Latin America are at risk of a wide range of disorders resulting from severe iodine deficiency and of these South East Asia has 280 million; Asia (other countries) 400 million; Africa 60 million. About 190 million people in these areas have goitres, 30 million of these come from Africa. There are approximately 3.15 million cretins in these areas and about 0.5 million are in Africa (3).

Several epidemiological studies have been done and have shown goitre to be prevalent in several parts of Africa especially in Central; West and East Africa (2, 7-13). In Malawi the percentage of total goitre rates (TGR) ranged from 50% - 85% while that of visible goitre ranged from 18 - 68% characterising a severe endemia (11). 2.5 million people are at
risk of developing goitre in this country (11).

In Lesotho a study done in children aged 6 - 12 years showed total goitre rates of 45% and visible goitre rates of 13% (14). In Ethiopia a national survey done between 1979-1981 showed that the prevalence of goitre ranged from 0.4% - 68.6%. It is estimated that 11 million people suffer from IDD in this country (14). In Madagascar a survey was done in Tananarive where 7538 breastfed infants were investigated. 31 children out of the total had visible goitres and 1 had congenital hypothyroidism. A total of 159 of these infants had increased TSH and low T₄ on day 5 of life. Goitrous mothers had iodine excretion of 4 microgrammes/ml in breast milk (BM) while non-goitrous mothers had iodine excretion of 7 microgrammes/ml in BM. (14).

In Rwanda a survey done in 1972 showed that 50% of adult men were goitrous while 60% of adult female were also goitrous. 21% of children below 12 yrs. were goitrous while those between 12 - 18 yrs. had goitre rates of 37% (14).

Studies done in Tanzania have shown that this country is endemic for goitre especially the Southern region. In the 1981 survey the TGR were 88.8%. In
1985 a survey done in 12 districts showed a TGR greater than 60%. Countrywide about 9.3 million people are at risk and about 160,000 cretins are in Tanzania. In 1986 a village survey showed a prevalence of 2% of myxoedematous cretins. (14).

In Zaire the northern regions are endemic for goitre. In a survey done in Ubangi region 70% of the population was goitrous and cretins constituted 6% of the population. Urinary Iodine excretion was less than 20 microgrammes/24 hrs. 306 zones were surveyed and 30 were found to be severely endemic while of these less than 10 have developed in the last few years. (14).

A study done in Zimbabwe in 1967 showed a total goitre rates of 60%. (14).

Although Kenya is not mentioned in the WHO Monograph (1960) as being endemic for goitre, surveys, which have been done since then have shown that the problem is very prevalent in some areas. (15-23).

The earliest reference to endemic goitre in Kenya was by Allen in 1926 who noted that goitre was
The first survey of endemic goitre in Kenya was carried out by a WHO nutrition team under Dr. J.A. Munoz between 1962-1964 who extensively surveyed the prevalence of endemic goitre in school children. Over 28,000 children in 103 schools spread over 14 districts were examined. Goitre rates varying from 15% to 72% were found, the highest rates being recorded from the highlands of Rift Valley, Central, Nyanza and Western Provinces. These results were reported by Bohdal et al. 1968 (16) to the Ministry of Health with an outline of the preventive measures to be taken. Cretinism was not reported in this survey. Further studies on endemic goitre were done in 1969 by the Medical Research Centre mainly by the Dutch (17). These studies were done among whole population groups in three areas of Kenya, i.e. Kericho and Nandi Districts of Rift Valley Province (Eburru, Buret and Nandi). These again indicated that a moderate to severe iodine deficiency existed in Kenya, causing a considerable amount of goitre in various parts of the country notable in the highlands of Kericho west. Urinary iodine excretion was said to be low. Endemic cretinism was again reported not to exist. In 1970 an experimental control programme was introduced through Iodination of locally produced salt. The effect
of the programme was assessed by doing studies in the areas already studied in 1969 i.e. Eburru, Buret and Nandi District of the Rift Valley Province.

Studies were done in 1972 and 1974 (2 years and 4 years after experimental Iodination respectively). The surveys did not show any significant reduction of goitre size (18,19) though the urinary Iodine excretion had increased. It was however felt that the three indicator groups of school children so far studied to monitor the goitre and Iodine Metabolism situation in Kenya were insignificant and a better representative sample was needed to follow the national situation accurately. For this purpose a study was designed in 1974 aimed to analyse nationwide data on Iodine excretion as a yardstick of iodine nutrition in the population (20). Eight children per school from a total of 59 schools visited in 30 districts and 2 Municipalities and comprising of 439 children in total with 231 boys and 208 girls were selected and their urinary iodine excretion determined in microgramme/24 hrs. The median values per school were calculated. The Eastern half of the country (Coast, Eastern and Central) roughly constituted a normal zone, while the Western half (Western, Nyanza and Rift Valley Provinces) shows a definite iodine deficiency.
The only survey where Baringo District is included was this last survey and only two schools (16 children) had been included in the 1974 National Survey. The Median Urinary Iodine excretion for Baringo District was 52 microgramme/24 hrs. This number of children studied from Baringo District is too small to be indicative of the real situation. The schools selected were not chosen so as to indicate if there was any difference in Iodine deficiency disorders between those staying in the Hills (highlands) and those in the lowlands. Furthermore the goitre rates and thyroid hormone assays were not done during this survey. It is also more than 14 years since this study was done and cannot depict what the true picture is at the moment as iodine metabolism in any given society is dynamic and several studies have shown new foci of endemic goitre in areas which before were not endemic (2).

Noting that a CSD (Child Survival and Development) programme has been started in Baringo District, a look at the status of IDD in some of its divisions is desirable at the moment. It is with this in mind that the author has set out to do this study.

Although surveys of school children are a useful method of assessing the prevalence and geographical
distribution of endemic goitre, there are certain disadvantages with this method of sampling. Firstly, although the goitre rate in young prepubertal children is a more sensitive index to the total goitre rate of the population than older pubertal children, these rates do not necessarily reflect the goitre rate of the total population in the area. Secondly, and more important, in the absence of compulsory education in Kenya, cases of mental and physical abnormality related to endemic cretinism are unlikely to be found in children attending school. No wonder then that no cretinism has been reported in all the school children surveys done in Kenya for endemic goitre. Intensive studies require therefore the study of whole population groups or cluster samples of these, preferable in a house to house survey. The results of this study should be the tip of the iceberg and therefore lead to further intensive studies later.
AIM: To assess the prevalence of IDD amongst school children aged 6 - 16 years in the two divisions of Baringo District.

OBJECTIVES:

1. Determine the goitre rates in school children aged 6 - 16 years in Marigat and Nginyang Divisions.

2. Determine thyroid hormone levels ($T_3$, $T_4$, TSH) in these children.

3. Determine the prevalence of chemical hypothyroidism in these children.
STUDY RATIONALE:

The national figures reflecting the problems of child survival and development (CSD) in Kenya as a whole are unfavourable.

The infant mortality rate (IMR) stands between 90 and 194 per 1000. This varies from one geographical area to another. In Baringo the IMR is 191 per 1000 and 19% of the under fives are stunted. Several activities are well known to influence child survival and development and these include immunization; diarrhoeal control; growth monitoring; community based health care, and health education as well as appropriate nutrition.

Despite the fact that Iodine Deficiency Disorders surveillance and control programmes have not been given a lot of publicity, nevertheless from the introduction of this presentation, they do have an impact on the IMR, PMR and the learning abilities of children. Hence, determination of the extent of IDD nationally is a most welcome idea especially when emphasising on the CSD programmes. This was more so in Baringo District where multidisciplinary approach to solving the problems of CSD had just
been started beginning from Marigat and Nginyang divisions and later to involve the whole district's seven divisions.

Secondly, of all the national surveys done in Kenya, Baringo district has been surveyed once. This was done in 1974 and only two schools were selected and a total of 16 children were investigated for urinary iodine excretion. No study has been done in this area to determine goitre rates and thyroid hormone profiles. Hence this study was appropriate and timely.

Lastly an intradistrict survey has not been done before in Kenya to show differences in IDD magnitude between the high areas and low areas. This fact demonstrates that even in a given district where goitre rates have been determined in earlier surveys there could be existing differences between various areas of varying altitude. There is always no linear correlation between increasing altitude and increasing goitre rates as has been demonstrated in this study.
MATERIALS AND METHODS

Area of Study:

Nginyang and Marigat divisions are two of the seven Administrative divisions in Baringo District of the Rift Valley Province.

Baringo district has a population of over 259,000 and covers an area of 10,638 sq. km. of land surface and 165 sq.km. of water surface in form of lakes Baringo, Bogoria and Kamnarok. The density of the population is between 20 - 30 persons per sq.km. For the whole of Baringo there are only 3 hospitals, 10 health centres and 41 dispensaries.

Education services are few and widely scattered. Only about 35-40% of the population is able to read and write.

The area of study is in a dry area with annual rainfall of about 600mm and is dominated by the woody vegetation of the Cammiphora - Acacia which are mostly of shrub habitat with thorn bushland. In Marigat division research is being carried out on some drought resistant species. Most rivers in these divisions are seasonal except for the Perkerra river which drains into Lake Baringo. Irrigation is carried out around Marigat using Perkerra river waters. The majority of the soils
in the lowland areas of these divisions are well drained shallow, stony and rocky, dark reddish brown and friable.

There are two major ethnic groups inhabiting the two divisions. The Pokot occupy Nginyang Division and their traditional diet is milk, blood and meat. Since their land is more or less dry throughout the year, the Pokot practice very little cultivation. The Ilchamus inhabit the Marigat division and are strictly pastoral people though the social changes that are taking place are forcing them to incorporate other food items into their traditional diet of milk and meat. Fish is eaten by those who reside near Lake Baringo. The Perkerra river irrigation scheme has led to some crops and vegetables being grown many of them for commercial purposes.

Among the ten commonest diseases in the District are respiratory infections, diarrhoeal disease, intestinal worms, skin infections, Kala azar and trachoma. Poor road communication between health facilities and the rural dwellers makes it hard for the rural people to get access to the health centres when need arises.
The prevalence of IDD in these divisions has not been elucidated and hence the need for such a study so that the child survival and development (CSD) programme going on in the area can be complemented.

There are at the moment a total of 45 primary schools, comprising a total of 7,500 children in Marigat division. Nginyang division has 21 primary schools with 2,045 children. Most of the schools in the divisions are boarding. This is to encourage children to attend school who would have otherwise not done so due to long distances between their areas of residence and the schools. The only setback is that some children move from one school to another while following their parents who lead a nomadic life and hence this statistics may change all the year round.

All the primary schools in the two divisions were divided into Lowland, highland or midzone schools depending on their altitude in relation to the lowest predetermined reference point for each division. The reference point for Marigat division is Lake Baringo and for Nginyang division is Chemolingot divisional headquarters. All the schools in the highland zone for the two divisions were then assigned numbers and two schools chosen randomly from each division. The
same was done for the Lowland schools in the two divisions. Schools in the midzone region of both divisions were excluded from the survey. 8 schools were therefore randomly selected in the two divisions comprising 4 schools per division. The schools selected and the number of children examined in the schools are as shown below:

**Nginyang Division:**

a) Lowland - Nginyang Primary School - 275 pupils were seen.
   - Chemolingot Primary School - 240 pupils were seen.

b) Highland - Churo Primary School - 263 pupils were seen.
   - Maron Primary School - 149 pupils were seen.

**Marigat Division:**

a) Lowland - Kampi Ya Samaki P.School - 422 pupils were seen.
   - Meisori Primary School - 140 pupils were seen.

b) Highland - Kaptorokwo Primary School - 286 pupils were seen.
   - Kapkiai Primary School - 220 pupils were seen.

A total of 1995 pupils were seen in the two divisions.
Before these children were examined, informed consent was obtained from the Assistant Education Officers and the Head-masters concerned. The children were fully explained about the nature of the survey. All these 1995 children were subjected to a clinical examination. The presence of a goitre was noted and any signs of hypothyroidism, hyperthyroidism or cretinism noted. If the lateral lobes of the thyroid gland had a volume greater than the terminal phalanx of the thumb of the pupil being examined the gland was considered enlarged. Goitre size was graded according to the WHO (modified Perez) Goitre classification (24) see appendix 4. All the clinical observations were made by one person (Researcher) to eliminate any inter-observer bias. The age and sex the children seen were noted. 200 children were randomly selected from the 8 schools included in the survey. Depending on the school attendance on the day of the survey a sampling interval was determined by use of the formula:

\[ \text{Sampling Interval} = \frac{n}{25} \]

Where \( n \) = total number of pupils present in a school on the day of the survey and 25 = number of children to be recruited per school. All the children were randomly assigned numbers. The first pupil was randomly selected and the rest of the pupils were selected following the sampling interval. For example in a school with 200 children the sampling interval would
be 8 and if the first pupil's number was 3, the subsequent pupils selected included numbers 11;19; 27; 35; etc till the 25th child was included. These children were then subjected to biochemical tests in addition to a clinical examination for the presence of a goitre and/or cretinism.

Blood was withdrawn from these 200 children into sterile iodine free containers and kept in a portable refrigerator and transported to Nairobi and where it was kept in a deep freezer awaiting analysis.

Serum levels of TSH, $T_3$ and $T_4$ using Radioimmuno Assay technique were determined in the department of Medicine. The Radioimmuno Assay kits used were the RIA-gnost (Behring) from Germany. The radioimmuno assay kit RIA-gnost (R) $T_4$ >> coated tube << permits in vitro determination of the total thyroxine ($T_4$) in human serum by the principle of the competitive protein binding analysis. With the aid of the displacement reagent 8 anilino-1-sulfonic acid (ANSA) the $T_4$ to be measured is displaced from the binding proteins and competes with $^{125I}-T_4$ for binding sites of a specific $T_4$ antibody which are available in limited numbers. The quantity of bound $T_4$ tracer is consequently inversely proportional to the $T_4$ concentration in the sample or standard. By
measuring the radioactivity of \(^{125}\text{I-}T_4\) bound to the antibody it is therefore possible to read off the serum \(T_4\) concentration from a standard curve established under identical conditions. The same principle applies for the determination of \(T_3\). (See appendix 3).

Determination of TSH is done using the RIA-gnost(R) hTSH reagent. This reagent permits in vitro determination of thyrotropin in human serum (or plasma) by the principle of a 1-step sandwich assay. During this process a complex of solid-phase anti-hTSH antibodies (Monoclonal, mouse) hTSH in the sample and \(^{125}\text{I-}\) labelled anti-hTSH antibodies (monoclonal, mouse) is formed. At the end of the reaction the free amount of tracer is removed by decanting (or aspiration) and subsequent washing.

The amount of tracer bound specifically to the coated test tubes is measured with a gamma counter.

Evaluation of the unknown samples is carried out by reading off from a standard curve constructed under identical conditions (25). Values of hTSH are as follows:-

- Normal thyroid function = 0.1 - 4 micro Int. U/ml.
- Hyperthyroidism = <0.1 " "
- Hypothyroidism = > 5 " "

Normal values for $T_4$ are 45 - 110 ng/ml
Normal values for $T_3$ are 0.6 - 1.9 ng/ml

Total Goitre Rates (TGR) is the prevalence of grades I + II + III. The visible Goitre Rates (VGR) is the prevalence of Grades II + III.
RESULTS

A total of 1995 children were seen in the age group 6 - 16 years in the two divisions of study. The males comprised of 1082 children (54%) and 913 females (46%).

A total of 154 goitre cases were seen in the two divisions. There were 68 goitre cases amongst males giving male goitre rates of 6.3% and females had 86 goitre cases giving females goitre rates of 9.4%. The average goitre rates in both males and females was 7.7%. These results are presented in table 1.

TABLE 1:

DISTRIBUTION OF GOITRE CASES BY SEX IN BOTH LOWLAND AND HIGHLAND SCHOOLS

<table>
<thead>
<tr>
<th>PUPILS EXAMINED</th>
<th>GOITRE CASES</th>
<th>GOITRE RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>1082</td>
<td>68</td>
</tr>
<tr>
<td>Females</td>
<td>913</td>
<td>86</td>
</tr>
<tr>
<td>Total</td>
<td>1995</td>
<td>154</td>
</tr>
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</table>
918 children were examined in the highland schools who comprised of 499 males (54%) and 419 females (46%). There were 21 goitre cases amongst males and 33 cases amongst females giving male goitre rates of 4.2% and female goitre rates of 7.9%. The overall goitre rates in the highland schools was 5.9%. These results are presented in table 2.

**TABLE 2:**

DISTRIBUTION OF GOITRE CASES BY SEX IN HIGHLAND SCHOOLS

<table>
<thead>
<tr>
<th>PUPILS EXAMINED</th>
<th>GOITRE CASES</th>
<th>GOITRE RATES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>499</td>
<td>21</td>
</tr>
<tr>
<td>Females</td>
<td>419</td>
<td>33</td>
</tr>
<tr>
<td>Totals</td>
<td>918</td>
<td>54</td>
</tr>
</tbody>
</table>
A total of 1077 children comprising of 583 males (54%) and 494 females (46%) were examined in the Lowland schools. The goitre rates for males and females were 8.1% and 10.7% respectively with an overall goitre rate of 9.3% in the Lowland children. These results are presented in table 3.

Table 3:

DISTRIBUTION OF GOitre CASES

BY SEX IN LOWLAND SCHOOLS

<table>
<thead>
<tr>
<th></th>
<th>PUPILS EXAMINED</th>
<th>GOITRE CASES</th>
<th>GOITRE RATES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>583</td>
<td>47</td>
<td>8.1%</td>
</tr>
<tr>
<td>Females</td>
<td>494</td>
<td>53</td>
<td>10.7%</td>
</tr>
<tr>
<td>Total</td>
<td>1077</td>
<td>100</td>
<td>9.3%</td>
</tr>
</tbody>
</table>

No clinical evidence of hypothyroidism, hyperthyroidism or cretinism was evident in this survey.
The distribution of the total goitre cases (154) in both the highland schools and the lowland schools by age group was as follows:

Age group 6 - 8 years had 27 goitre cases ($m=12$, $f=15$) and this comprised of about 18% of all goitres.

There were 53 goitre cases ($m=26$; $f=27$) in the age group 9 - 12 years and this constituted about 34% of all goitres. The age group 13 - 16 years had 74 goitre cases ($m=30$; $f=44$) and this comprised of about 48% of all goitre cases. These results are presented in the bar chart shown in figure 1.
Figure 1:

Distribution of goitre cases by age group and sex.
STATISTICAL ANALYSIS:
Significance of the difference in goitre rates between the males and females and between children from Lowland and those from the highland was done using the chi square ($x^2$) test. When tested for sex the value of $x^2 = 6.83$. Hence there was a statistically significant difference between males and females with females being more affected than males ($p < 0.05$).

The value of $x^2 = 8.055$ when the difference between children from highland were compared with those from the lowland. Hence there is a statistically significant difference between highland dwellers and lowland dwellers in the area of study with the lowland children affected more than the highland children ($p < 0.05$).

No statistical analysis could be done to determine any difference between the various age groups in terms of goitre rates as shown in figure 1 as the children who had no goitres were not evaluated for age. There are however more females than males with goitres in the pubertal/adolescent age group (13 - 16 years) than in the pre-pubertal/pre-adolescent age groups where males almost equal the females in goitre cases.
In the second part of the survey, out of the 1995 school children seen in the two divisions, 200 children were randomly selected to undergo biochemical tests on top of clinical examination. 197 children were included in the analysis for age, sex, and goitre rates as forms for 3 children were misplaced.

160 children were included in the analysis for thyroid hormone levels as the rest of the 40 specimens had either no labels, or had insufficient serum or their corresponding forms had gotten misplaced.

Of the 197 children analysed for age, sex and goitre rates, 48 children were in the age group 6-8 years; 80 children in age group 9 - 12 years and 69 children between 13-16 years age group. Their goitre rates were 10.4%, 11.3% and 15.9% respectively with an average goitre rate of 12.7% (see table 4).
The 197 children were comprised of 116 males and 81 females whose distribution by age group is represented in table 5.

Table 5:
DISTRIBUTION OF GOITRE CASES BY AGE GROUP

<table>
<thead>
<tr>
<th>AGE GROUP</th>
<th>CHILDREN EXAMINED</th>
<th>GOITRE CASES</th>
<th>GOITRE RATE%</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 - 8yrs.</td>
<td>48</td>
<td>5</td>
<td>10.4%</td>
</tr>
<tr>
<td>9 - 12yrs</td>
<td>80</td>
<td>9</td>
<td>11.3%</td>
</tr>
<tr>
<td>13 - 16yrs</td>
<td>69</td>
<td>11</td>
<td>15.9%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>197</td>
<td>25</td>
<td>12.7%</td>
</tr>
</tbody>
</table>
There were 25 goitre cases out of the randomly selected 197 children.

There were 10 goitre cases out of the 116 males examined and 15 goitre cases out of the 81 females examined giving goitre rates of 8.6% and 18.5% respectively. The overall goitre rate in the 197 children was 12.7%. The results are shown in table 6.

**TABLE 6:**

DISTRIBUTION OF GOITRE CASES BY SEX

<table>
<thead>
<tr>
<th>PUPILS EXAMINED</th>
<th>GOITRE CASES</th>
<th>GOITRE RATES %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>116</td>
<td>10</td>
</tr>
<tr>
<td>Females</td>
<td>81</td>
<td>15</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>197</strong></td>
<td><strong>25</strong></td>
</tr>
</tbody>
</table>

Out of the 10 goitre cases in males, 1 was in age group 6-8 years, 3 in age group 9 - 12 years and 5 in age group 13 - 16 yrs. The 15 goitre cases in females were distributed as follows:

- 6 - 8 years age group - 4 cases
Figure 2:
Distribution of goitre cases by sex and age group.
STATISTICAL ANALYSIS

Analysis to show whether there were any difference in goitre rates between the various age groups was done using the chi square ($x^2$) test using the formula $x^2 = \sum \frac{(O - E)^2}{E}$.

There was no significant difference in goitre rates between the various age groups despite the fact that there seems casually to be a rise in goitre rates with increasing age ($x^2 = 0.55; d.f. = 2; p > 0.05$).

Analysis was also done to show whether there was any sex difference in goitre rates in the various age groups using Fisher's Exact test. In the age group 6 - 8 years the value of $x^2 = 0.0656$ while the value of $x^2 = 0.2335$ in the age group 9-12yrs. $X^2 = 0.00823$ in the age group 13 - 16 years. From this analysis no significant sex difference exists in the various age groups as far as goitre rates are concerned ($p > 0.05$).

In both the Lowlands and the highlands there was no visible goitres (Grade II and III) but only palpable goitres (Grade Ia and Ib). The results of the goitres by grades in the highland and Lowland
regions are represented in figure 3. There were a total of 100 cases of goitre in the Lowland out of which 88 goitre cases (88%) were grade Ia while 12 cases (12%) were grade Ib. In the highland, out of 54 goitre cases 45 cases (83%) were grade Ia and 9 cases (17%) grade Ib. There is statistically no difference in goitre grades between Lowland and Highland ($x^2=0.69; \text{d.f.}=1; p > 0.05$).

![Graph showing distribution of goitre cases by area and by goitre grade.](image)

**Figure 3:** Distribution of goitre cases by area and by goitre grade.
Also the goitres were analysed by grades for the boys and girls. There were a total of 63 goitre cases amongst boys out of which 58 cases (85%) were grade Ia and 10 cases (15%) were grade Ib. The girls had a total of 86 goitre cases out of which 75 cases (87%) were grade Ia and 11 cases (13%) were grade Ib. The results are represented in fig. 4.

Figure 4: Distribution of goitre cases by sex and goitre grade.
There was no statistically significant difference in goitre grades between males and females \( (x^2=0.12; d.f. = 1; p > 0.05) \).

The difference in goitre cases between Marigat and Nginyang divisions was also analysed. A total of 927 children were seen in Nginyang Division out of which 68 had goitres. There were a total of 1068 children in Marigat division out of which 86 had goitres. This is represented in table 7 below:

TABLE 7:

DISTRIBUTION OF GOITRES BY DIVISION

<table>
<thead>
<tr>
<th></th>
<th>Goitres</th>
<th>Without Goitres</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NGINYANG</td>
<td>68</td>
<td>859</td>
<td>927</td>
</tr>
<tr>
<td>DIVISION</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MARIGAT</td>
<td>86</td>
<td>982</td>
<td>1068</td>
</tr>
<tr>
<td>DIVISION</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>154</td>
<td>1841</td>
<td>1995</td>
</tr>
</tbody>
</table>

Using the chi-square \( (x^2) \) test there was no significant difference in goitre rates between the two divisions of Baringo district.
\( (x^2 = 0.358; d.f. = 1; p > 0.05) \)
Out of the 160 children whose results for thyroid hormone levels were determined, majority had normal \( T_3 \), \( T_4 \) and T.S.H. 33 out of 160 children had high \( T_3 \) (20.6%). No child had low \( T_3 \) levels. There were 17 children with low \( T_4 \) levels out of 160 children (11.6%). No child had high \( T_4 \).

There were 34 children with high TSH out of 160 children (21%). These results are presented in table 8.

**TABLE 8:**

RESULTS OF THYROID HORMONE (\( T_3, T_4 \) AND TSH) ASSAY:

<table>
<thead>
<tr>
<th></th>
<th>LOW</th>
<th>HIGH</th>
<th>NORMAL</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSH</td>
<td>-</td>
<td>34</td>
<td>126</td>
<td>160</td>
</tr>
<tr>
<td>( T_3 )</td>
<td>-</td>
<td>33</td>
<td>127</td>
<td>160</td>
</tr>
<tr>
<td>( T_4 )</td>
<td>17</td>
<td>-</td>
<td>143</td>
<td>160</td>
</tr>
</tbody>
</table>
The mean values ($\bar{x}$) of serum TSH and their standard deviations ($s$) were calculated for both the highland schools and lowland schools as well as for the girls and boys.

In the Lowland the mean ($\bar{x}$) TSH value was 3.30 μIU/ml with a standard deviation of 2.87, while in the lowland $\bar{x} = 2.35$ μIU/ml with a standard deviation of 2.47.

Using the student t-test the value of $t = 2.25$. Hence there is a significant difference between the mean TSH value for the lowland and that for the highland, being higher in the lowland ($p < 0.05$; d.f = infinity).

The $\bar{x}$ value for girls = 3.13 with a standard deviation of 2.85, while the $\bar{x}$ value for boys = 2.87 with a standard deviation of 2.77. By using the student t-test the value of $t = 1.30$. Therefore there is no significant difference between the mean TSH value for girls and that for boys ($p > 0.05$; d.f = infinity).
DISCUSSION

This survey was done in the month of May, a period which is similar to the one used by earlier researchers and therefore no seasonal variation is expected when comparing these results and those done earlier. Seasonal variation in iodine metabolism has been noted in a number of studies. These have shown that there is more urinary iodine excretion in winter than summer (30).

The overall TGR was 7.7% a figure which signifies a mild endemia of IDD. Urinary iodine excretion estimations was necessary but could not be done in our laboratory reliably by the time of presentation of this results. Mild endemicity of iodine deficiency disorders is characterised by goitre rates of 5 - 20% and median daily iodine excretion of greater than 50 ug/g creatinine but less than 100 ug/g creatinine. This mild endemicity of IDD is not expected to be associated with the presence of cretins in the environment. Endemic cretinism is said to occur when goitre rates are 30% or more with median urine iodine excretion below 25ug/g creatinine (31). No wonder then that no cretinism was observed during this survey. Clinical hypothyroidism which was not observed in this
survey occurs when the endemicity is moderate. This mild endemicity may not be similarly found in the area if whole population sample surveys are done. This is due to the fact that these children are privileged a lot in this population, and as most of the schools are boarding or offer lunch in school the iodine consumption could differ from the one in the general population of the same area.

Analysis of the goitre rates in respect of sex shows that females are significantly more affected than males ($p < 0.05$). This has been the experience in many studies (13, 32). The influence of female sex hormones on iodine metabolism may be playing a role but is not conclusively established. With the exception of children in the 0 - 6 years age groups it has been found that females have higher goitre rates and larger goitres (visible goitres) than males.

In this survey it has been shown that there were significantly more children from the Lowland affected with goitres than those from the highland. Other earlier studies from other regions in Kenya stated that goitres were more common in the highland than in the lowland due to iodine being washed down from the highlands. Studies have however, not been
done in any one given area to show differences between the higher regions and the lower regions of the same area. Similar results as in this study have been observed in other endemic areas. This has been shown to be due mainly to flooding which occurs in the Lowland with subsequent loss of iodine from the soil (33,34).

These results however, are contradictory to the commonly observed results that goitre rates are much more common the higher the altitude. In Latin America, Uruguay in particular, the goitre rate increases from the sea-shore to the Andean Corderilla (35) and in the Huon peninsula of Papua New Guinea, a direct correlation between visible goitre rates and altitude has been demonstrated (36). In Kenya, the same trend has been observed before. In Eburru at 9,000 feet above sea level the goitre rate in school children was 83%. In nearby Nakuru, at 5,500 feet, the goitre rate was 30% according to the W.H.O. survey (16). During this survey it was noticed that the highlands were greener with more foliage covering the soil than in the lowland such that flooding and easy erosion of the lowland soils could account for the higher goitre rates in the lowland than in the highland. The other possible explanation is due to poor quality of drinking water in the lowland than in the highland. This has been described before
from as early as 770 B.C. (37) to the present day (38). McCarrison observed that goitre increased from the top to the bottom of a series of villages in the Gilgit valley, India, and suggested that the drinking of polluted water was responsible (39). Bacterial contamination of drinking water may be responsible for the modest endemic goitre which has been described in the presence of apparently adequate nutrition in Kentucky (40) and in northern Virginia (41). The role of other possible goitrogens in water such as calcium and fluoride in aggravating the endemic of Iodine Deficiency Disorders in this region has not been exploited. It was observed in this survey that the water in the lowland was rather dirty or muddy compared to the clean looking highland waters. Bacterial contamination was not studied however.

No visible goitres (Grade II + III) were seen in this survey. All goitres were of grade Ia + Ib. There was no statistically significant difference in goitre grades between the highland and lowland, and between the females and males. The fact that smaller grades of goitre were seen in this survey probably means that either the iodine deficiency has not been longstanding or, and the iodine deficiency is mild. The latter explanation has already been demonstrated by goitre rates in the mild endemic range. From previous studies in other areas of the country the prevalence of visible
goitre rates (VGR) was shown to decrease significantly in three areas studied i.e. Buret, Kericho; Kaptumo, Nandi and Eburru (19). The rate of decrease of VGR in Eburru was 6.4% annually ($p < 0.001$). In Buret the rate of decrease was 5.3% annually, ($p < 0.001$) and in Kaptumo 2.1% annually ($p < 0.001$). It is therefore, also possible that the VGR in this area have diminished to nil with time following introduction of iodised salt.

The prevalence of chemical hypothyroidism in many surveys has been based on TSH estimations alone as this is a sensitive indicator of thyroid activity. Raised TSH has the advantage of being a far more sensitive test of thyroid insufficiency which is capable of detecting the disease in various conditions where the level of circulating hormones has not yet changed (Job et al 1972; Shenkman et al, 1973; Hayek et al, 1973; Gordin et al, 1974; Barnes, 1975). The prevalence of chemical hypothyroidism using serum $TSH > 5$ micro International units/ml is 21% from this study. This is by far much more than the total goitre rates of 7.7% seen in this study. This finding has also been reported from various other studies (26). In the Tanzania study it was found that school children exposed to severe iodine deficiency, hypothyroidism as detected by TSH levels
of more than 5 micro units/ml was more prevalent than increased thyroid volume (goitre). These data show clearly that in children, hypothyroidism as indicated by increased TSH levels prevails over goitre size as a consequence of iodine deficiency. There was no correlation between TSH levels and the presence of a goitre in this study. This was also the experience in Tanzania (26) where they found that thyroid volumes had no correlation with urinary iodine excretion or with TSH levels.

The prevalence of chemical hypothyroidism using serum T₄ levels less than 45 ng/ml is approximately 11%. This is almost half the prevalence of hypothyroidism as detected by high TSH levels. This still affirms the sensitivity of TSH estimations. The prevalence of elevated T₃ levels (serum T₃ levels greater than 2 ng/ml is approximately 20% in this study. In iodine deficiency serum T₄ is decreased and serum T₃ increased. There is no doubt that there is preferential biosynthesis and secretion of T₃ from the thyroid gland (27,28,29). Dilution of the iodine in the enlarged thyroid is the main cause of the poor iodination of thyro globulin that is found. This in turn, results in increased MIT/DIT and T₃/T₄ ratios observed in thyroid tissue and the preferential secretion of T₃. T₃ contains 25% less iodine than T₄ and it is 4 times more potent on a
weight basis. The economy of iodine, thus achieved is obvious.

The mean serum TSH levels were significantly higher in the lowland than in the highland \((p < 0.05)\). This shows that a part from the fact that there were more goitres in the lowland, hypothyroidism is significantly much more there also than in the highland. The mean serum TSH levels were not significantly different between males and females \((p > 0.05)\).
A mild endemia of iodine deficiency disorders exists in Marigat and Nginyang divisions of Baringo district. There is no statistical difference between these two divisions in terms of their prevalence of goitre rates. This calls for consumption of iodated salt as such a measure will prevent this endemia.

Females are significantly affected more than males and the role of hormonal influence on iodine/thyroid hormone metabolism is not fully established.

Children in the lowland are much more affected than those from the highlands in terms of goitre rates and the mean values of serum TSH. This could be due to flooding and probably goitrogens.

There is no correlation between goitres and TSH levels or T4 levels. No evidence of cretinism was seen in this survey.

Further work needs to be done in order to find out the role of goitrogens in causation of iodine deficiency disorders in this area. Also to be looked at is the extent or scope of iodine deficiency
disorders in a house to house survey as school surveys could be biased especially in this semiarid area where school attendance is quite poor.
ACKNOWLEDGEMENTS

1. My supervisors: Prof. Meme, J.S. and Dr. Orinda D. for their advise and criticisms which proved invaluable.

2. The lecturers and residents in the department of Paediatrics for the vital criticism they offered during the presentation of the protocol and the results of this study.

3. The Administration, Education Officers, Headmasters, teachers and school children in Baringo District, who were involved in this survey, for their cooperation without which the survey could not have succeeded.

4. The department of Paediatrics, University of Nairobi for their financial assistance.

5. Mr. Omondi, T. a biochemist in the department of Medicine, for technical assistance in the laboratory work.

6. Prof. Brady, J., Dr. Orinda, V. and Mr. Nyabola, for their assistance in statistical analysis of the data.

7. My wife, Mrs. Jane Nyakundi, for her patience during the survey and write-up of this work.

8. Mrs. G. Mazonde for her invaluable secretarial assistance.
APPENDIX 1

MAP OF NGINYANG AND MARIGAT DIVISIONS

NGINYANG DIVISION
- Marong Primary
- Chemolingot Primary
- Nginyang Primary

MARIGAT DIVISION
- Kaptorokwo Primary
- Kapkiai Primary

Lake Bogoria

Lake Baringo

Kampi ya Samaki Primary
Meisori Primary

▲ SCHOOLS IN THE HIGHLAND SURVEYED
● LOWLAND SCHOOLS SURVEYED
APPENDIX 2:

THE STUDY OF THE PREVALENCE
OF IODINE DEFICIENCY DISORDERS (IDD) IN
NGINYANG AND MARIGAT DIVISIONS OF BARINGO DISTRICT

(Questionnaire)

1. Name: ......................................................
2. Code No.: ..................................................
3. Age (yrs): ............................................... 
4. Class: .....................................................
5. School: ...................................................
6. Division: ...................................................
7. Height (cm): .............................................
8. Weight (kg): .............................................
9. Goitre by class
   - 1a
   - 1b
   - II
   - III
10. Blood sample taken
    - yes
    - No
11. Urine sample taken
    - yes
    - No
12. Period of residence in the area (years)...
13. Source of water:
    - river
    - shallow wells
    - Borehole
    - others (state)
APPENDIX 3: EXAMPLE OF A STANDARD CURVE USED FOR THYROID HORMONE LEVEL MEASUREMENT

ng/ml
APPENDIX 4:

THE WHO (MODIFIED PEREZ) GOITRE CLASSIFICATION:

Grade 0 - No goitre

Grade Ia - Goitre detectable only by palpation and not visible even when the neck is fully extended.

Grade Ib - Goitre palpable and visible only when the neck is fully extended.

Grade II - Goitre visible with the neck in normal position; palpation is not needed for diagnosis.

Grade III - Very large goitres readily visible from a considerable distance.
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