Goitre in Ethiopia

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A stratified goitre survey was conducted on 35635 schoolchildren and 19158 household members in all Regions of Ethiopia except Eritrea and Tigrai. The gross goitre prevalence (mean of male and female values) among schoolchildren and household members was 30·6 and 18·7% respectively, while that of visible goitre was 1·6 and 3·2% respectively. Prevalence was higher in females (27·3% in household members and 36·1% in schoolchildren) than in males (10·1% in household members and 25·1% in schoolchildren) and increased with age more in females than in males. The prevalence rates at higher altitudes were higher than those at lower altitudes in both schoolchildren and household members. Using an epidemiological model the consequences of iodine deficiency, including cretinism and maternal wastage, have been estimated.

Goitre: Iodine: Cretinism

Iodine deficiency disorders (IDD) encompass a variety of conditions including goitre, mental disorders and milder psychomotor defects, abortions, stillbirths, and increased perinatal and infant mortality. Goitre was known to the Hindus as early as 2000 BC, to the Egyptians by 1500 BC, and in Western Europe in the 1st century AD (Langer, 1960). In Ethiopia there is a lack of historical documentation on the occurrence of goitre, as is the case for many other diseases. Nevertheless, early travellers in the country and physicians during the Italian invasion of Ethiopia in the Second World War reported cases of goitre in various parts of the country (Kelly & Snedden, 1960). More recent studies demonstrated that goitre is one of the nutrition diseases of public health significance in certain areas of the country (Interdepartmental Committee on Nutrition for National Defence, 1959; Demonstration and Evaluation Team, 1965; Popov, 1967; Hofvander, 1970; Miller *et al.* 1976). The primary objective of the present study was to estimate the prevalence of goitre throughout the country. A second objective was to estimate the prevalence of other manifestations of IDD based on epidemiological models relating the prevalence of these manifestations to that of goitre.

MATERIAL AND METHODS

Sampling

The study was conducted in the period between March 1980 and July 1981. Data on the population of urban and semi-urban areas, altitude, and agroecological zones were obtained from the Central Statistical Authority, Mapping Authority, and Ministry of

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Agriculture respectively. All Administrative Regions of the country were studied except Eritrea and Tigrai which were excluded for security reasons. First-stage stratification was based on the population of the urban and semi-urban areas while subsequent stratification was based on Administrative Region and altitude, since 89% of the population of the country live in areas more than 1400 m above sea level (Kloos *et al.* 1988). Schoolchildren and household members were studied.

In towns where there was more than one government primary school, one was selected in consultation with the educational authorities in order to ensure that those selected for the survey of schoolchildren were representative of all sectors in the area. All children present on the day of examination were included. Through such a procedure, a total of 35635 schoolchildren (19159 boys and 16476 girls) were enrolled in the study.

In the household survey, a total of 19158 subjects (7649 males and 11509 females) were examined in forty-two urban and semi-urban settings. The study sites were in thirty-eight provinces with a population of over 19 million out of the total of eighty-five provinces in the country which has a population of 50 million (Office of the Population and Housing Census Commission, 1984). All households in smaller semi-urban settings or in two 'kebeles' (urban dwellers' associations) in larger towns were registered by personnel employed for the purpose. From this list of households, 160 households were selected at random. All members of the selected households were requested to come to one central area, usually the kebele office or the local health institution for physical examination. The enumerators went to the houses when subjects did not report on time. Despite this effort, it was not easy to contact all adult males because of their preoccupation with their daily routine and reluctance to undergo health examination. A predesigned questionnaire was used to register members of households, their ages, sex, relationship to head of household, goitre grade and duration of stay in the area. On the same questionnaire, data on staple diet, frequency of consumption of kale (*Brassica carinata*), availability and type of latrine and source of drinking-water were also collected to determine whether there was any relationship between these variables and the occurrence of goitre. Consumption of goitrogens in foods including kale and faecal contamination of drinking water are putative goitrogenic factors (Gaitan, 1980).

Physical examination

The physical examination of all subjects was carried out by two of the authors (Z.W.-G., T.D.). Goitre classification was compared and standardized at the start of examinations at each new study site and at regular intervals throughout the survey. The thyroid gland was examined and graded according to techniques recommended by Perez *et al.* (1960) and modified by DeLange (1974) where grade 0 corresponds to no goitre, IA is palpable but not visible, IB is goitre easily visible with the neck extended, II is visible without extension of the neck, and III is large goitre visible from a distance. When the goitre grading was in doubt, the lower stage was always chosen. In the present study, gross goitre included stages IA, IB, II and III while visible goitre included stages II and III. Whenever nodular goitre was diagnosed, this was noted along with the goitre grade.

Estimation of IDD rates

Cretinism was estimated from an epidemiological model based on existing data from Asian countries, Zaire and Ecuador (Clugston *et al.* 1987; Hetzel *et al.* 1990). The symbols used have been modified for the sake of clarity:

$$c_g = \exp(b_0 + b_i g + b_{ii} g^2)/[1 + \exp(b_0 + b_i g + b_{ii} g^2)],$$

where c_g is prevalence (proportion) of cretinism estimated from the prevalence of gross goitre, g is prevalence (proportion) of gross goitre, b_0 −9·3939, b_i 15·796, and b_{ii} −8·8026.

The rates (proportion of live births) of reproductive losses namely, neonatal death, stillbirth and miscarriage/infertility were estimated as follows:

$$l_n = m_n c_g,$$

where m_n is multiplier for l_n, c_g is prevalence (proportion) of cretinism estimated from the prevalence of gross goitre, l_i is rate of neonatal death (m_i 0·602), l_{ii} is rate of stillbirths (m_{ii} 0·656), and l_{iii} is rate of miscarriage/infertility (m_{iii} 0·883).

Mild developmental handicaps, namely developmental delays, psychomotor defects and reduced mental performance, were estimated by multiplying prevalence of cretinism by three (Clugston *et al.* 1987; Hetzel *et al.* 1990). The calculations were carried out using the prevalence of goitre from the household survey since similar data were used in deriving the equations. The goitre rates for both sexes together were calculated by taking the mean of the rates for males and females. The 1990 population projection was based on the 1984 census of Ethiopia (Office of the Population and Housing Census Commission, 1984) while the crude birth rates were from the 1984 Regional census (Office of the Population and Housing Census Commission, 1989). The national crude birth rate used in the calculations was a weighted mean of the regional rates taking into account the number of household members examined in each region.

Statistics

Chi square test and multiple regression analysis were used for determining the significance of differences and correlations respectively.

RESULTS

School survey

The prevalence of goitre among schoolchildren at the different study sites by administrative regions of Ethiopia is shown in Table 1. The prevalence (mean of rates for boys and girls) of gross goitre among schoolchildren was 30·6% while that for visible goitre was 1·6% (Table 1). The prevalence of goitre was higher in schoolchildren living at higher altitudes than those at lower altitudes. The prevalence predictions have not been normalized for altitude. The slope (s) and intercept (i) of the linear regression of gross goitre (%) on altitude (m) (means with their standard errors) are: (n 41, r 0·37, s 0·0114 (SE 0·0046), i 6·03 (SE 9·37)).

More girls were found to have goitre than boys (Tables 1 and 2). The difference between the sexes became more pronounced with age (Table 2). In boys the prevalence dropped from about 25% for those 18 years of age and younger to less than 10% for those 19 years of age and older. In girls, the prevalence continued to increase with age from 20% in girls 0–5 years to more than 42% in those 19 years of age and over. The sex (male:female) ratio for gross goitre was 1:1·3 for the age-group 6–12 years, 1:1·6 for 13–18 years, and 1:5·3 for those above 19 years of age. From among those with visible goitre, twenty-one (5·7%) had nodular goitre.

Household survey

In the household survey an overall gross goitre prevalence of 10·1% in males and 27·3% in females (mean of rates for males and females 18·7%) was found (Table 3). Visible goitre prevalence was 0·34% in males and 5·9% in females (mean of males and females 3·1%). The rate of visible goitre was lower than 4% in males in all regions, while in females a rate as high as 32·9% was seen in Gondar town. Of those subjects with visible goitre, only thirty-one, 4·4%, had nodular goitre which was seen at fifteen of the study sites. Assuming that the sample population is representative for the whole country, 2·5 million males and 6·8 million females would have goitre while 85000 males and 1·5 million females

Table 1. *Prevalence of goitre in schoolchildren studied at various sites in Ethiopia*

Region	No.*	Study site	Altitude (m)	Examined		Goitre prevalence							
						Male				Female			
						Gross		Visible		Gross		Visible	
				Male *n*	Female *n*	*n*	%	*n*	%	*n*	%	*n*	%
Arssi	1	Bekoji	2835	566	437	204	36·0	1	0·5	252	57·7	7	1·6
	2	Dierra	1780	443	340	49	11·1	0	0·0	58	17·1	0	0·0
Assab	3	Assab	170	619	544	34	5·5	0	0·0	65	11·9	0	0·0
Bale	4	Adaba	2420	445	480	236	53·0	2	0·4	288	60·0	9	1·9
	5	Ghinir	1970	520	621	70	13·5	0	0·0	116	18·7	3	0·5
Gamo-Gofa	6	Felegeneway	1430	513	264	295	57·5	44	8·6	207	78·4	51	19·3
	7	Gidole	2090	768	448	54	7·0	1	0·1	115	25·7	6	1·3
Gojjam	8	Burie	2200	384	327	176	45·8	11	2·9	188	57·5	27	8·3
	9	Chagnie	1690	515	550	261	50·7	1	0·2	336	61·1	3	0·5
	10	Injibara	2640	386	263	134	34·7	1	0·3	142	54·0	4	1·5
	11	Tis-Abay	1720	229	208	64	24·9	0	0·0	89	42·8	0	0·0
Gondar	12	Debarek	2850	490	529	237	48·4	12	2·4	340	64·3	22	4·2
	13	Gondar	2250	1427	1472	887	62·2	40	2·8	1107	75·2	121	8·2
	14	Koladuba	1890	321	395	101	31·5	1	0·3	166	42·0	7	1·8
Hararge	15	Alemaya	2030	140	114	6	4·3	0	0·0	5	4·4	0	0·0
	16	Bedessa	1790	355	339	65	18·3	2	0·6	116	34·2	7	2·1
	17	Idora†	920	—	—	—	—	—	—	—	—	—	—
Illubabor	18	Jijiga	1690	492	485	18	3·7	0	0·0	18	3·7	1	0·2
	19	Gambella	520	487	281	52	10·7	2	0·4	60	21·4	9	3·2

Kefa	20	Gore	2025	629	639	156	24·8	5	0·8	216	33·8	5	0·8
	21	Agaro	1770	816	872	95	11·6	0	0·0	159	18·2	3	0·3
Shoa	22	Bonga	1800	385	368	70	18·2	0	0·0	108	29·3	4	1·1
	23	Ambo	2120	854	785	166	19·4	0	0·0	269	34·3	7	0·9
	24	Ataye	1500	361	355	16	4·4	0	0·0	37	10·4	0	0·0
	25	Awash	1015	243	221	0	0·0	0	0·0	2	0·9	0	0·0
	26	Butajira	2090	425	310	101	23·8	7	1·6	114	36·8	7	2·3
	27	Chancho	2510	286	263	68	23·8	6	2·1	115	43·7	17	6·5
	28	Emdibir	2125	886	420	84	9·5	0	0·0	87	20·7	1	0·2
	29	Gohatsion	2520	342	266	145	42·4	2	0·6	151	56·8	9	3·4
	30	Mehalmeda	3060	404	365	27	6·7	1	0·2	67	18·4	1	0·3
	31	Mojo	1850	417	424	8	1·9	0	0·0	32	7·5	1	0·2
Sidamo	32	Sheboka	1820	418	192	140	33·5	3	0·7	77	40·1	1	0·5
	33	Boditi	2100	254	111	29	11·4	2	0·8	10	9·0	0	0·0
	34	Dilla	1760	570	491	54	9·5	0	0·0	71	14·5	5	1·0
	35	Hagereselam	2790	269	177	27	10·0	0	0·0	35	19·8	0	0·0
	36	Yavello	1320	397	285	3	0·8	0	0·0	7	2·5	0	0·0
Wellega	37	Assosa	1680	305	284	97	31·8	3	1·0	140	49·3	4	1·4
	38	Guye	2030	297	86	169	56·9	19	6·4	41	47·7	1	1·2
Wollo	39	Assaita	460	282	254	43	15·2	0	0·0	54	21·3	0	0·0
	40	Haik	1990	441	410	116	26·3	5	1·1	135	32·9	9	2·2
	41	Lalibela	2470	357	318	171	47·9	5	1·4	189	59·4	8	2·5
	42	Wereillu	2685	421	483	76	18·1	1	0·2	161	33·3	8	1·7
		Total		19159	16476	4804	25·1	177	0·9	5945	36·1	368	2·2

* No. indicated in Fig. 1 on the map to show study sites.
† School survey not conducted.

Table 2. *Distribution of goitre grades by age and sex amongst schoolchildren at various sites in Ethiopia**

Age (years)	No. examined	Goitre grade† 0		IA		IB		II		III		Total goitre	
		n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Male													
0–5	19	14	73·7	5	26·3	0	0·0	0	0·0	0	0·0	5	26·3
6–12	13406	10002	74·6	2495	18·6	832	6·2	77	0·6	0	0·0	3404	25·4
13–18	5390	4023	74·6	901	16·7	369	6·8	92	1·7	5	0·1	1367	25·4
19+	344	316	91·9	20	5·8	5	1·5	3	0·9	0	0·0	28	8·1
Sub-total	19159	14355	74·9	3421	17·9	1206	6·3	172	0·9	5	0·0	4804	25·1
Female													
0–5	30	24	80·0	3	10·0	3	10·0	0	0·0	0	0·0	6	20·0
6–12	11724	7732	66·0	2587	22·0	1252	10·7	149	1·3	4	0·0	3992	34·0
13–18	4534	2667	58·8	1003	22·1	669	14·8	186	4·1	9	0·2	1867	41·2
19+	188	108	57·4	32	17·0	28	14·9	18	9·6	2	1·1	80	42·6
Sub-total	16476	10531	63·9	3625	22·0	1952	11·8	353	2·1	15	0·1	5945	36·1

* For details of prevalence and sites, see Table 1 and Fig. 1.
† For details of classification, see p. 258.

would have visible goitre (data from Table 3). Prevalence did not differ between males and females in the 0–5 years age-range (4·1% in both), but was significantly higher ($P < 0·001$) in females than in males thereafter (Table 4). Of the males aged 13–18 years, 30% were found with goitre while 45% females of the same age-group had goitre. The sex difference was even more marked in the age-group 19 years and older where the prevalence in males had decreased to 6·4% while in females it had increased to 46·0%. The sex ratio of goitre was 1·0 for under 5-year-old children 1:1·2 for the 6–12-year-olds, 1:1·5 for the 13–18-year-olds and 1:7·2 for the 19 years and above age-group.

As for the schoolchildren, the prevalence of goitre was higher in household members living at higher altitudes than in those at lower altitudes. The regression of gross goitre (%) on altitude (m) (means with their standard errors) was: (n 41, r 0·41, s 0·0083 (SE 0·0035), i 3·52 (SE 6·41)).

There was a high correlation between gross goitre prevalence in schoolchildren and household members (r 0·897, $P < 0·001$). Data on gross goitre in household members were used to estimate other forms of IDD in the population of the areas surveyed. For the more severe forms in survivors, the rate of cretinism was estimated to vary from 0·09 to 16 per 1000 of the population. Assuming that the population surveyed was representative of the country, the number of cretins in Ethiopia in 1990 was estimated at 59000 (1·17 per 1000) while three times as many, 176000 persons (3·51 per 1000), may show some degree of developmental and neurological function impairment attributable to Iodine deficiency. The estimated annual national toll in 1990 (rates per 1000 live births) of reproductive losses attributable to Iodine deficiency were as follows: neonatal deaths 13600, stillbirths 14800, infertility/miscarriage 20000.

From the data collected on whether excreta was disposed of in a pit latrine, water-flushed toilet or in the open air, no relationship was seen with goitre size. Neither was a relationship seen with kale consumption, seasonally or all year round, or with the source of drinking water from pipe, well, spring or river.

Table 3. *Prevalence of goitre in household members studied at various sites in Ethiopia*

Region	No.*	Study site	Population 1990 Male	Population 1990 Female	Birth rate 1990†	Examined Male *n*	Examined Female *n*	Goitre prevalence: Male Gross *n*	Male Gross %	Male Visible *n*	Male Visible %	Female Gross *n*	Female Gross %	Female Visible *n*	Female Visible %
Arssi	1	Bekoji	3141	3337	42·3	180	207	58	32·2	0	0·0	115	55·6	15	7·2
	2	Dierra	2729	3146	42·3	167	254	6	3·6	0	0·0	27	10·6	4	1·6
Assab	3	Assab	18035	18036	39·3	157	290	9	5·7	0	0·0	36	12·4	0	0·0
Bale	4	Adaba	3487	4339	48·6	199	267	49	24·6	1	0·5	126	47·2	11	4·1
	5	Ghinir	5000	5202	48·6	230	345	18	7·8	0	0·0	52	15·1	6	1·7
Gamo-Gofa	6	Felegeneway	4464	4471	45·9	153	207	28	18·3	2	1·3	97	46·9	50	24·2
	7	Gidole	4554	5417	45·9	175	254	12	6·9	0	0·0	61	24·0	15	5·9
Gojjam	8	Burie	4319	5388	41·3	194	310	56	28·9	6	3·1	158	51·0	42	13·5
	9	Chagnie	4530	5466	41·3	196	306	54	27·6	1	0·5	168	54·9	56	18·3
	10	Injibara	544	1231	41·3	160	284	25	15·6	0	0·0	127	44·7	7	2·5
	11	Tis-Abay	1477	1927	41·3	179	256	45	25·1	0	0·0	129	50·4	23	9·0
Gondar	12	Debarek	4214	5858	44·7	143	251	28	19·6	1	0·7	135	53·8	42	16·7
	13	Gondar	34915	46946	44·7	155	225	37	23·9	3	1·9	127	56·4	74	32·9
	14	Koladuba	2943	5173	44·7	110	196	6	5·5	0	0·0	68	34·7	13	6·6
Hararge	15	Alemaya	3788	4203	43·7	190	308	3	1·6	0	0·0	12	3·9	0	0·0
	16	Bedessa	4030	3869	43·7	191	244	5	2·6	0	0·0	42	17·2	5	2·0
	17	Idora	703	837	43·7	68	107	0	0·0	0	0·0	1	0·9	0	0·0
Illubabor	18	Jijiga	12897	14625	43·7	140	258	0	0·0	0	0·0	10	3·9	1	0·4
	19	Gambella	2788	2544	37·9	168	264	5	3·0	0	0·0	23	8·7	4	1·5

Table 3 (cont.)

Kefa	20	Gore	3539	4346	37·9	281	371	21	7·5	2	0·8	103	27·8	13	3·5
	21	Agaro	11325	10950	41·6	232	331	5	2·2	1	0·4	80	24·2	15	4·5
Shoa	22	Bonga	3373	4005	41·6	144	275	13	9·0	0	0·0	85	30·9	7	2·5
	23	Ambo	9660	10906	38·2	212	326	27	12·7	0	0·0	62	19·0	11	3·4
	24	Ataye	2463	3013	38·2	129	217	3	2·3	0	0·0	24	11·1	2	0·9
	25	Awash	2349	2631	38·2	163	266	0	0·0	0	0·0	16	6·0	3	1.1
	26	Butajira	7719	8529	38·2	251	323	27	10·8	4	1·6	111	34·4	38	11·8
	27	Chancho	1466	2008	38·2	135	255	9	6·7	0	0·0	60	23·5	18	7·1
	28	Emdibir	840	1107	38·2	183	308	16	8·7	0	0·0	86	37·9	10	3·2
	29	Gohatsion	1538	2177	38·2	186	299	52	28·0	1	0·5	151	50·5	46	15·4
	30	Mehalmeda	2406	2862	38·2	121	210	0	0·0	0	0·0	47	22·4	4	1·9
	31	Mojo	7587	8967	38·2	165	250	0	0·0	0	0·0	30	12·0	1	0·4
Sidamo	32	Sheboka	1350	1798	38·2	215	293	19	8·8	0	0·0	76	25·9	3	1·0
	33	Boditi	2525	2701	38·6	144	215	9	6·3	0	0·0	37	17·2	8	3·7
	34	Dilla	14322	14092	38·6	245	288	6	2·4	0	0·0	37	12·8	6	2·1
	35	Hagereselam	1537	1641	38·6	185	269	0	0·0	0	0·0	22	8·2	3	1·1
	36	Yavello	3573	3533	38·6	208	296	0	0·0	0	0·0	10	3·4	1	0·3
Wellega	37	Assosa	2480	2457	31·2	283	413	54	19·1	1	0·4	162	39·2	21	5·1
	38	Guye	553	681	31·2	276	288	37	13·4	1	0·4	112	38·9	18	6·3
Wollo	39	Assaita	4005	4139	39·6	164	284	0	0·0	0	0·0	42	14·8	5	1·8
	40	Haik	2582	3419	39·6	262	397	19	7·3	2	0·8	109	27·5	11	2·8
	41	Lalibela	2747	3382	39·6	136	244	12	8·8	0	0·0	99	40·6	54	22·1
	42	Wereillu	2715	3445	39·6	174	258	3	1·7	0	0·0	72	27·9	11	4·3
		Total				7649	11509	776	10·1	26	0·3	3147	27·3	677	5·9

* No. indicated in Fig. 1 on map to show study sites.

† Birth rate, number of live births per 1000 population per year (Office of the Population and Housing Census Commission (1989).

Table 4. *Distribution of goitre grades by age and sex amongst all household members at various sites in Ethiopia**

Age (years)	No. examined	Goitre grade† 0		IA		IB		II		III		Total goitre	
		n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Male													
0–5	4079	3913	95·9	156	3·8	9	0·2	1	0·0	0	0·0	166	4·1
6–12	1951	1521	78·0	369	18·9	55	2·8	5	0·3	1	0·1	430	22·0
13–18	315	219	69·5	75	23·8	15	4·8	6	1·9	0	0·0	96	30·5
19+	1304	1220	93·6	53	4·1	18	1·4	10	0·8	3	0·2	84	6·4
Sub-total	7649	6873	89·9	653	8·5	97	1·3	22	0·3	4	0·1	776	10·1
Female													
0–5	4106	3938	95·9	159	3·9	4	0·2	0	0·0	0	0·0	168	4·1
6–12	2265	1645	72·6	483	21·3	114	5·0	23	1·0	0	0·0	620	27·4
13–18	652	356	54·6	152	23·3	90	13·8	53	8·1	1	0·2	296	45·4
19+	4486	2423	54·0	823	18·3	640	14·3	503	11·2	97	2·2	2063	46·0
Sub-total	11509	8362	72·7	1617	14·0	853	7·4	579	5·0	98	0·9	3147	27·3

* For details of prevalence and sites, see Table 1 and Fig. 1.
† For details of classification, see p. 258.

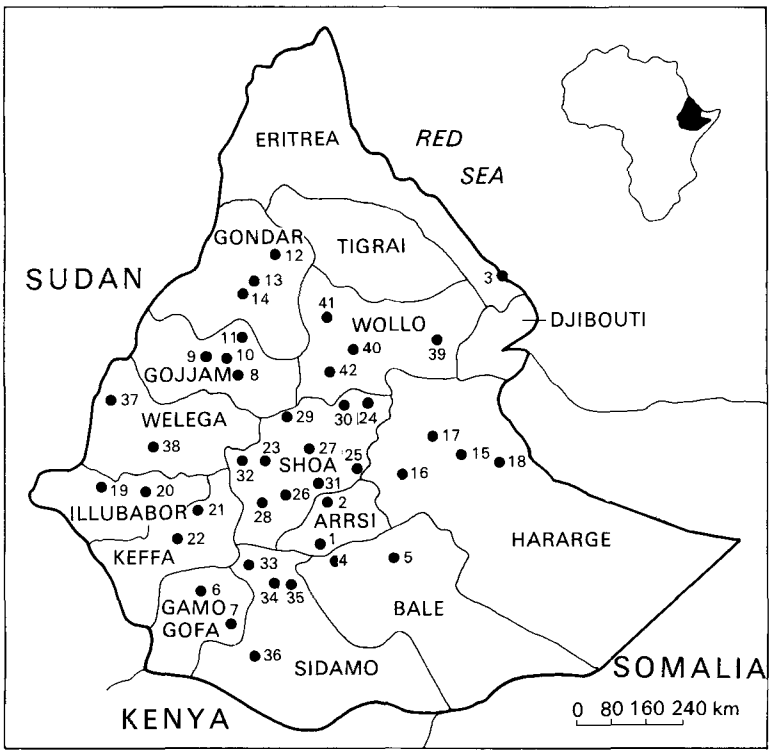

Fig. 1. Map of Ethiopia showing administrative regions and study sites.

DISCUSSION

Studies carried out in the past have demonstrated that IDD existed in Ethiopia (Interdepartmental Committee on Nutrition for National Defence, 1959; Kelly & Snedden, 1960; Demonstration and Evaluation Team, 1965; Popov, 1967, Hofvander, 1970; Miller *et al.* 1976) and that in certain pocket areas the prevalence may be as high as 71% (Miller *et al.* 1976). However, the present study is the first which has been designed to provide a representative overview of the severity and extent of IDD in the country. The goitre prevalence in schoolchildren found in the present survey was 30·6% which is regarded as severe according to the classification of Hetzel (1987). This rate is not as high as that reported from other African countries, such as Tanzania with 47·8% (Kavishe, 1986). However, many surveys have not been as representative as the present survey which was stratified and covered the whole country. The present survey showed that, in schoolchildren in particular and in household members in general, the prevalence of goitre increased with age and reached its peak in the prepubertal and pubertal age in both sexes, but diminished in adulthood in males and plateaued after a slight decrease in females. These findings are in agreement with observations made elsewhere, such as in Sudan and Tanzania (Eltom *et al.* 1984; Kavishe, 1986). In the household study group of the present survey the sex ratio for goitre prevalence was 1:1·5 in subjects aged 13–18 years and 1:7·2 in those 19 years of age and over.

Studies from other areas of the world have suggested that goitre prevalence is associated with soils of Pre-Cambrian origin (Wilson, 1954; Thilly *et al.* 1972), suboptimal Iodine intake (Beckers & DeLange, 1980), excessive Iodine intake possibly leading to autoimmune thyroiditis (Mu *et al.* 1987), high Ca, Mg and F consumption (Langer, 1960; Day & Powell-Jackson, 1972; Gaitan, 1980), Se deficiency (Vanderpas *et al.* 1990), goitrogenic components in the diet (Ermans *et al.* 1980; Klopfenstein *et al.* 1983; Osman *et al.* 1983), bacterial contamination of drinking water (Gaitan, 1980) and malnutrition (Ingenbleek & Beckers, 1973; Ingenbleek & De Visscher, 1979; Gaitan *et al.* 1983). The results of the present study could find no associations with kale consumption, availability and type of latrine or source of drinking water, but a relationship was found with altitude.

There was a positive correlation between goitre prevalence and altitude amongst schoolchildren as well as household members. The correlation was relatively stronger among the household members which may be related to a longer period of exposure to a fixed Iodine intake. In addition to the relationship between goitre prevalence and altitude, there was variation in prevalence within the same range of altitude among the different study sites, particularly in lowland areas. Thus, the prevalence in household members in Felegeneway which lies at an altitude of 1430 m was 33% while it was less than 8% at all the other sites below 1500 m. It is also noteworthy that next to Gondar the highest prevalence of visible goitre was observed here.

A possible explanation for goitre prevalence at high altitudes might be the leaching of Iodine from the highland areas, although no assessment of Iodine content of foods, water and soil was done during the present study. However, the Iodine content of salt from the Red Sea is low when compared with that from more open oceans (Interdepartmental Committee on Nutrition for National Defence, 1959, and a report by a World Health Organization consultant, P. Subrimanian, unpublished results). The Iodine content of food and soils from goitrous areas in Ethiopia has also been shown to be low (Z. Wolde-Gebriel and C. E. West, unpublished results). Some people in highland regions obtain their food from Iodine-rich areas and this will help to increase Iodine intake. Other factors such as goitrogens may reduce the availability of Iodine.

Assessment of schoolchildren is a simple and cheap method for determining the extent and magnitude of IDD in a community as children are readily accessible and representative.

In the areas we surveyed, the schoolchildren were from different socio-economic groups of society and ate at home and, thus, their general dietary pattern should reflect that of the community in which they live. In the present study the prevalence rate of goitre in schoolchildren reflected that in household members. Very low or zero rates of goitre were observed both in schoolchildren and household members in certain areas such as Alemaya, Jijiga, Awash and Yavello, while high prevalence rates were observed in both groups in other areas such as Gondar, Debarek, Tis-Abay and Felegeneway.

Furthermore, the present study was conducted in semi-urban and urban areas where the inhabitants rely on food produced in the surrounding rural areas. Thus, the Iodine intake of the people surveyed may not be very different from that of those who live in the nearby surrounding areas. Since the sites sampled were evenly distributed throughout the country, we believe that the findings are representative.

Although an enlarged thyroid gland by itself does not affect a subject's health, except when the goitre is so large that it compresses the trachea, its aesthetic implications especially in girls has social implications in many rural areas. Thus, many goitrous women said that they found it difficult to find husbands and that those with large goitres did not aspire to university, after successfully passing their examination, out of fear of comments from others.

With regard to the other manifestations of IDD, excellent reviews on brain development and reproductive disorders in relation to Iodine deficiency and thyroid function have been prepared by Hetzel and his colleagues (Hetzel & Querido, 1980; McMichael *et al.* 1980). Relationships between Iodine deficiency and thyroid function on the one hand, and reproductive failures, poor educational performance and physical development on the other hand have been documented from many places. These developmental IDD are very important problems of public health significance but are generally neglected by health professionals and decision makers. Applying previously-developed epidemiological models to the results from the population studied, which is assumed to be representative of the whole country, it is estimated that there are 59000 cretins and 176000 cretinoids in Ethiopia. Classically, as predicted from the epidemiological model presented, cretinism is regarded as a problem in areas where the prevalence of goitre is more than 50%. From the present study we know that there are certain pocket areas with such high rates of prevalence and this could explain the existence of cretinism in such areas.

Thus, IDD would appear to be a serious threat to the health and well-being of the people residing in goitre-endemic areas. Cretins are social and economic burdens to the households and communities in which they live and to the nation as a whole. The estimates at least indicate the magnitude of the problem and highlight a very serious problem which deserves the attention of health professionals at the level of research, policy formulation and programme action, and a commitment to intervention from government. As far as research is concerned, efforts should be made to overcome the paucity of information on the impact of Iodine deficiency and Iodine supplementation on maternal welfare. As far as programmes are concerned, the salt iodination effort which has been initiated should be encouraged so that iodinated salt can reach all goitrous areas. In view of the difficult terrain and the poor transport, distribution and marketing infrastructure of the country, the use of iodized oil capsules in difficult and inaccessible areas should also be considered.

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