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This paper is dedicated to all children everywhere--enjoy your lollipops while you can.

ABSTRACT

The extent of anemia was investigated in 1789 individuals under the care of the Hill Health Center. All were under 21 years old and resided in an inner-city neighborhood of New Haven, Conn. The study group was made up of 56% Black, 33% Spanish-speaking (Puerto Rican), and 11% White individuals. 3% were under 10 months of age; 15%, 10-36 months; 50%, 3-10 years; 17%, 10-14 years; and 15%, 14-21 years. Individuals with sickle cell disease or hookworm infestation were not included in the study. The results reveal that 12.5% of those 10-36 months, 4.4% of those 3-10 years, and 2.4% of those 10-14 years were anemic according to the hematocrit criteria used. Of interest was the fact that 13.5% of the females and 1.2% of the males 14-21 years old were found to be anemic by hematocrit determination; utilizing hemoglobin values, 33% of the females and 8.6% of the males over 14 years were classified as anemic. Ethnic differences were noted among 10-14 year olds and especially among teenage girls; in these groups, Black children had lower mean values and a higher frequency of anemia than either White or Puerto Rican children. The high frequency of anemia during the first few years of life has been documented; but these results indicate the need for continuing concern for teenagers residing in the inner city. The results suggest that nutrition counselling and supplemental iron when indicated should continue beyond infancy to include adolescents.

INTRODUCTION

Some fifty years ago, MacKay[1] in England documented the almost universal prevalence of nutritional anemia among the poor infants and children of London's East End, and demonstrated the efficacy of dietary iron fortification in preventing the condition. During the 1930s, Guest in the United States reached similar conclusions in his studies of children in Cincinnati, noting the direct relationship between increased frequency and severity of iron deficiency anemia and lower socio-economic class. This same author repeated his study in 1957,[2] and found the incidence of anemia among infants (30%) unchanged thirty years after his initial investigation.

Nutritional anemia remains today the major deficiency disease of early childhood in the United States, a manifestation of the marginal nutritional status of a high proportion of the nation's young. Recent surveys[3-14] of both urban and rural areas have revealed varying incidences of iron deficiency anemia in different geographic areas, in part a reflection of real differences and in part a reflection of different investigators' criteria for defining "anemia." In general, however, a pattern has emerged showing a physiologic peak of nutritional iron deficiency anemia during the second year or so of life, a period of accelerating growth during which inadequate dietary intake of iron is most likely to jeopardize normal hemoglobin synthesis.

In spite of the recent flurry of investigation, major gaps in our knowledge about the epidemiology of nutritional anemia remain. Although it is clear that lower socio-economic group children are at a higher risk, no systematic information about ehtnic differences in the

occurrence of nutritional anemia is available. In New York City, for instance, Hullman and Smith[3] have noted that among Black, White and Puerto Rican families studied in Brooklyn, a significantly higher proportion of Blacks suffered from iron deficiency anemia than in the other groups; on the other hand, Haughton[4] found no such differences among children studied at New York City child health stations.

Nor do we have broad-based knowledge about age differences in the incidence of anemia. Almost all of the recent surveys cited are confined to investigation of children under six years of age. Only Pearson[5] has surveyed children from infancy, through puberty. In his study of an homogeneous Black population in the Gainesville, Florida area, he found that, as expected, the incidence of nutritional anemia reached a peak of 15% during the second year of life and then with decrease of growth rate and the assumption of a more varied diet through later childhood, gradually disappeared. With the onset of puberty, however, the "marginal correction" of girls began to reverse itself, with iron deficiency anemia occurring in 8% of the teenage girls studied and in almost 25% of those studied in the third trimester of pregnancy. More work is needed to determine if this age-related pattern of incidence is generally characteristic of the overall pediatric population.

Even less clear are the precise associations of iron deficiency anemia with morbidity in the pediatric age group. Only a few isolated studies have dealt with this area. It has been pointed out that hospitalized infants, in general, exhibit an unusually high incidence of iron deficiency anemia.[14,15] It has been suggested (but by no means proven) in a study by Andleman and Sered[7] in Chicago that nutritionally

anemic infants have more frequent, complicated respiratory infections than non-anemic infants. Other studies have tried to associate iron deficiency anemia with feeding disturbances, pica, behavioral disturbances, learning problems and occult blood loss.[16,17,18] At present, these findings remain assertions, rather than facts; and it has been suggested[18] that clinical management of nutritional anemia ought to reflect our current belief that the state is the measurable hematological manifestation of a general malnutrition problem. With present knowledge of iron balance and requirements in infancy,[19] this gives impetus to official recommendations that all infant formulas and foods be iron-fortified.[20]

The present retrospective study establishes the prevalence of iron deficiency anemia in a group of 1789 ambulatory children from an inner-city community of New Haven, Connecticut, according to age, ethnic group and sex; future investigation will correlate these findings with morbidity, and attempt to determine the effect of dietary iron fortification in infancy on the prevalence on anemia in the same community.

METHODS

Data were obtained from the laboratory records of individuals under twenty-one years of age served by the Hill Health Center from June, 1968 through September, 1970. The Center, a federally-funded comprehensive child health care program, is a new health resource in a low-income community of some 21,000 Black, White and Spanish-speaking (basically Puerto Rican) residents, with an estimated pediatric population of 8,000. When a child is enrolled for care in the program, he receives immediate

episodic care as needed; and as soon as possible an initial health assessment is performed which includes the collection of capillary blood for hematological tests. Hematocrits are determined using the microhematocrit technique; hemoglobin values are established using the cyanmethemoglobin method.

The population studied consisted of 1789 children enrolled at the Hill Health Center during its first two years of operation. Only initial hematocrit and hemoglobin values for an individual were used, the majority of these being determinations made during routine initial health assessments. Some values, however, were obtained not simply as part of the screening procedure, but because the pediatrician was concerned about the possibility of anemia. Four children with known hemoglobinopathies (sickle cell disease) were excluded from the study, as were a number of Puerto Rican children with anemia secondary to hookworm infestation. It was assumed that the remaining cases of anemia discovered in the population were due primarily to nutritional iron deficiency.

Of the 1789 individuals studied, 56% were Black; 11% were White; and 33% were Puerto-Rican. Age groups for the project were defined as follows: group 1, age 0-9 months, constituting 3% of the sample population; group 2, age 10 months-3 years, 15% of the population; group 3, age 3-10 years, 50% of the population; group 4, age 10-14 years, 17% of the population. Groups 5 and 6 were males and females, respectively, age 14-21 years; group 5, the males, constituted 6% of the sample population while group 6, the females, constituted 9%.

Mean hematocrit and hemoglobin values for each age group (and by sex for groups 5 and 6) were compared with normal values based on Albritton;[21] the percentage of anemic individuals in each group was

based on the following table of "lower limits of normal," derived from Wintrobe:[22]

TEST	AGE under 10 months	10mos.--3years	3--10 years	10--14 years	(Female) 14--21 years	(Male) 14--21 years
Hemoglobin (Gm%)	---	9.8	10.5	11.0	12.0	12.5
Hematocrit (%)	---	31	32	34	35	36

Infants 0 to 9 months (group 1) were not analyzed both because nutritional anemia is highly unusual in this group and because normative values change from week to week. For comparison of mean hematocrits and hemoglobins among Blacks, Whites and Puerto-Rican children within each age and sex group, a one-way fixed-effects analysis of variance was used, based on Hays.[23]

RESULTS

Results are summarized in Tables 1 through 3 and Figures 1 through 10. Table 1 indicates mean hemoglobin values for each study group, the comparable normal means, and the percent anemic in each group. All sample means are significantly lower than normal means. 17.5% of infants 10 months to 3 years old are anemic; this percentage declines until the teen-age years, when a moderate increase in anemia among males (8.6%) and an extreme increase among females (32.7%) is noted.

Table 2 shows similar results using hematocrit values. Only 1743 of the 1789 individuals studied had microhematocrits performed along with hemoglobinometry. The percent anemic in each age group is lower using hematocrit as opposed to hemoglobin as a measure, and the trend

towards increasing anemia among adolescent males is not apparent. No satisfactory explanation for these discrepancies, noted occasionally in other studies too, is available; various workers, however, suggest placing greater confidence in hematocrit values, which do not depend on somewhat unreliable laboratory methods for determining corpuscular hemoglobin. Interestingly, the mean hematocrit for the 9 month--3 year sample group of 257 individuals was not significantly lower than normal.

Table 3 compares directly the results obtained by Pearson[5] in his study of nutritional anemia in Gainesville, Florida, and similar data from the present study. Figures were extracted from the New Haven data using the age-group and normative-value criteria established by Pearson. Although the population thus surveyed from New Haven was somewhat smaller than that in Gainesville (650 versus 2800 individuals), and not ethnically homogeneous, the results are remarkably similar. Means for children in New Haven, ages 9--18 months, 4--6 years and 12--14 years are significantly higher than those in Gainesville, but remain lower than normal.

Figures 1 and 2 present ethnic comparisons within each age group for hemoglobin and hematocrit data from the Hill Health Center, respectively. It can be seen that there are no constant differences across age groups among Black, White and Spanish-speaking children either in terms of group means or percent anemia. Significant differences in mean values do occur, however, particularly among 10--14 year olds wherein Blacks exhibit lower means (and a greater percentage of anemia) than either Whites or Puerto-Ricans, and among teenage females, where the most extreme ethnic difference become manifest. Here, Black females have a mean hemoglobin of 12.0 Grams % and a mean hematocrit of 37%, both well below

normal. 44% of Black teenage girls were found anemic on the basis of hemoglobin criteria; 21% on the basis of hematocrit. Note that in comparing these findings with those of Pearson for female adolescents in Gainesville, nutritional anemia seems to be a more prevalent problem among black females in New Haven. No important differences in hematological status between White and Spanish-speaking children were detected in the present study, although a number of individuals from the latter group were excluded from the study because of fairly severe anemia resulting from intestinal parasitism contracted in Puerto Rico.

Figures 3--10 are percentage distribution curves for hemoglobin and hematocrit values, by age agroup. They have fairly normal curvatures, indicating probably representative population sampling. Of concern is the fact in every age group there is a small but real proportion of seriously anemic children. Note in Figure 10, which displays hematocrit values for teenage males and females, the bimodality of the curve for males. This suggest that included in this sample are both prepubertal and post-pubertal individuals. Indeed, if strictly adult norms are used in establishing criteria of anemia in this age-sex group, an erroneously high percentage of anemic individuals results.

DISCUSSION

The results of this study are similar to those of other surveys designed to detect nutritional anemia in that they demonstrate a high prevalence of iron deficiency during the early years of life, particularly the second and third years. In line with Pearson's work, the study documents the decrease of nutritional anemia during later childhood, and its upsurge in adolescent females, in whom, presumably, a marginal

nutritional adaptation is inadequate to cope with the demands of puberty and menstruation.

What is suggested for the first time, however, is a trend in adolescence towards increased nutritional inadequacy not confined solely to females. Excluding those with hemoglobinopathies and Puerto Rican immigrants with parasitic infestations, there remained in this study several adolescent males from low-income families among the 82 surveyed who had clear iron deficiency anemia (with hypochromia and microcytosis on smear). Certainly the number of individuals is too small to allow a confident statement; and those surveyed, enrolled as they were in a health care program, may not have been representative of a peer group tending to utilize health services only minimally. But taken with the somewhat high frequency of anemia found in the study among 10--14 year olds (6.2% by hemoglobin; 2.4% by hematocrit)--a group in whom physiologic "correction" has presumably occurred--and the very high prevalence of iron deficiency among adolescent females, these results suggest the need for continuing concern regarding the nutritional status of older children and adolescents in lower socio-economic groups.

Such a conclusion is reinforced by the finding of ethnic differences in both mean hematologic values and the prevalence of anemia among 10--14 year olds and adolescent girls. In these groups, Blacks were more subject to nutritional anemia than either Whites or Puerto Ricans. The basis of these differences remains to be elucidated. But the need for concern and further investigation is clear. In our eagerness to correct the dietary problems of infancy, we ought not to forget that iron deficits and nutritional inadequacies occur at other ages as well, and need counselling and correction when discovered and in order to be prevented.

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TABLE 1. HEMOGLOBINS OF 1789 CHILDREN AT THE HILL HEALTH CENTER

GROUP	AGE	NUMBER	MEAN HEMOGLOBIN (gm %)	STD. DEVIATION (gm %)	NORMAL MEAN HEMOGLOBIN (gm %)	LOWER LEVEL of NORMAL (gm %)	PER CENT ANEMIC
1	0-9 mos.	72	11.2	---	---	---	---
2	10-36 mos.	269	11.1[x]	1.7	11.8	9.8	17.5
3	3-10 yrs.	912	12.2[x]	3.1	12.6	10.5	6.8
4	10-14 yrs.	305	12.6[x]	1.1	13.5	11.0	6.2
5 (male)	14-21 yrs.	81	14.2[x]	1.6	15.8	12.5	8.6
6 (female)	14-21 yrs.	150	12.6[x]	2.7	13.9	12.0	32.7

[x] All means significantly lower than normal at $p < .05$

TABLE 2. HEMATOCRITS OF 1743 CHILDREN AT THE HILL HEALTH CENTER

GROUP	AGE	NUMBER	MEAN HEMATOCRIT (%)	STD. DEVIATION (%)	NORMAL MEAN HEMATOCRIT (%)	LOWER LEVEL of NORMAL (%)	PER CENT ANEMIC
1	0-9 mos.	68	35.4	---	---	---	---
2	10-36 mos.	257	35.1[x]	3.9	35.0	31.0	12.5
3	3-10 yrs.	880	36.6[xx]	3.2	38.0	32.0	4.4
4	10-14 yrs.	297	38.4[xx]	3.0	39.5	34.0	2.4
5(male)	14-21 yrs.	82	42.6[xx]	4.2	47.0	36.0	1.2
6(female)	14-21 yrs.	159	38.2[xx]	3.9	42.0	35.0	13.8

[x] Not significantly different from normal mean
[xx] Significantly lower than normal mean at $p < .05$

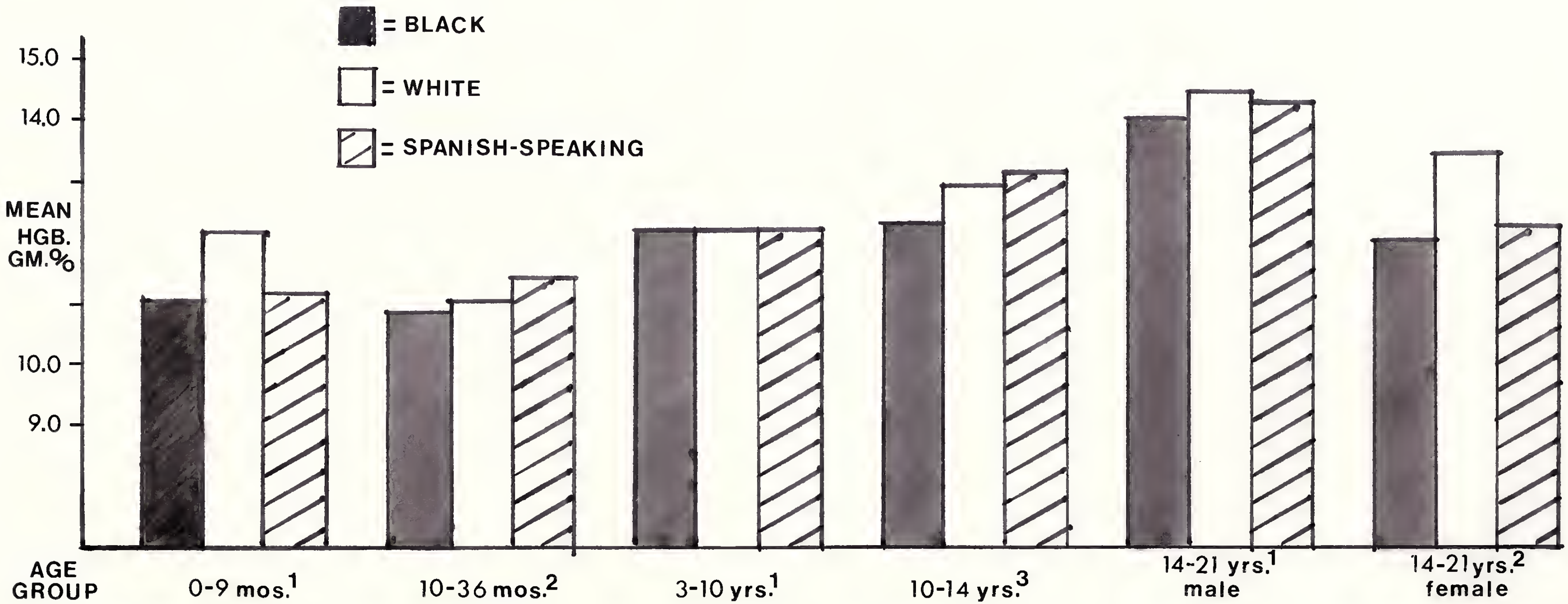
TABLE 3. HEMATOCRITS–COMPARISON BTWN. NEW HAVEN, CT. & GAINESVILLE, FLA.

GROUP	AGE	NORMAL MEAN HEMATOCRIT %	LOWER LEVEL of NORMAL %	NUMBER	MEAN HEMATOCRIT %	PER CENT ANEMIC	SIGNIF. OF DIFFERENCES BETWEEN MEANS
1	9-18 mos.	35.0	30.0	g. 244 nh. 97	32.2 34.1	14.8 11.3	$p < .05$
2	4-6 yrs.	37.5	32.0	g. 1450 nh. 310	35.6 36.2	4.5 7.4	$p < .05$
3	12-14 yrs.	39.6	34.0	g. 726 nh. 117	38.1 38.7	2.6 0.9	$p < .05$
4-male	14-17 yrs.	– – –	– – –	g. 163 nh. 49	43.2 42.2	– – –	n.s.
5-female	14-17 yrs.	42.0	34.0	g. 220 nh. 72	38.8 37.9	8.0 11.1	n.s.

g. = gainesville

nh. = new haven

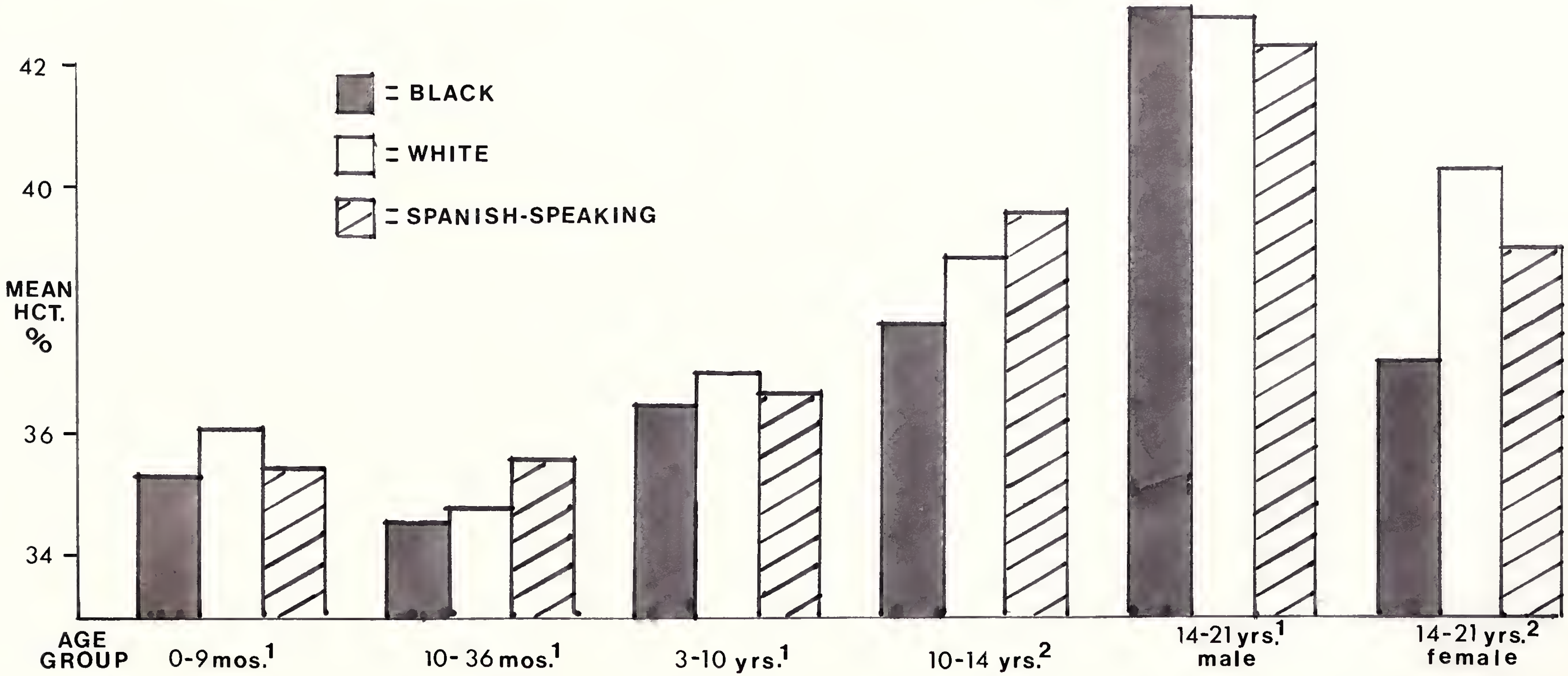
FIG.1 HEMOGLOBINS, ETHNIC COMPARISONS AMONG 1789 CHILDREN AT THE H.H.C.



AGE GROUP	0-9 mos.[1]			10-36 mos.[2]			3-10 yrs.[1]			10-14 yrs.[3]			14-21 yrs.[1] male			14-21 yrs.[2] female		
NUMBER	31	7	34	123	31	115	538	106	268	184	41	80	50	9	22	77	10	63
% ANEMIC	------			19.5	19.4	14.8	6.7	4.7	7.8	9.2	2.4	1.3	10.0	11.1	4.5	44.2	20.0	20.6

1: Means not significantly different
2: ,, ,, ,, at $p < .05$
3: ,, ,, ,, at $p < .01$

FIG. 2 HEMATOCRITS, ETHNIC COMPARISONS AMONG 1743 CHILDREN AT THE H.H.C.



AGE GROUP	0-9 mos.[1]			10-36 mos.[1]			3-10 yrs.[1]			10-14 yrs.[2]			14-21 yrs.[1] male			14-21 yrs.[2] female		
NUMBER	30	7	31	119	30	108	517	102	261	181	41	75	50	9	23	82	10	67
% ANEMIC	- - -	- - -	- - -	14.3	13.3	10.2	4.1	3.9	5.4	3.3	2.4	0.0	2.0	0.0	0.0	20.7	0.0	7.5

1: Means not significantly different
2: " " " at $p < .05$

FIG. 3 DISTRIBUTION OF HEMOGLOBINS IN 269 CHILDREN – h.h.c.
AGE 10mos.– 3yrs.

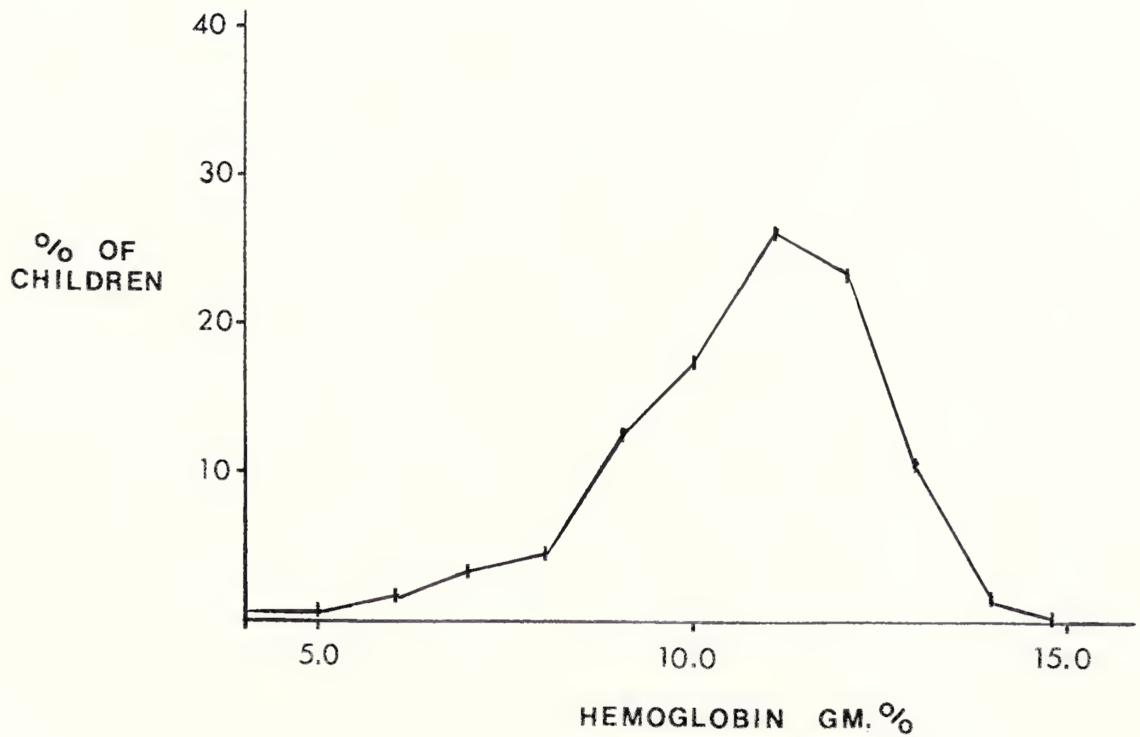


FIG. 4 DISTRIBUTION OF HEMATOCRITS IN 257 CHILDREN – h.h.c.
AGE 10mos. - 3 yrs.

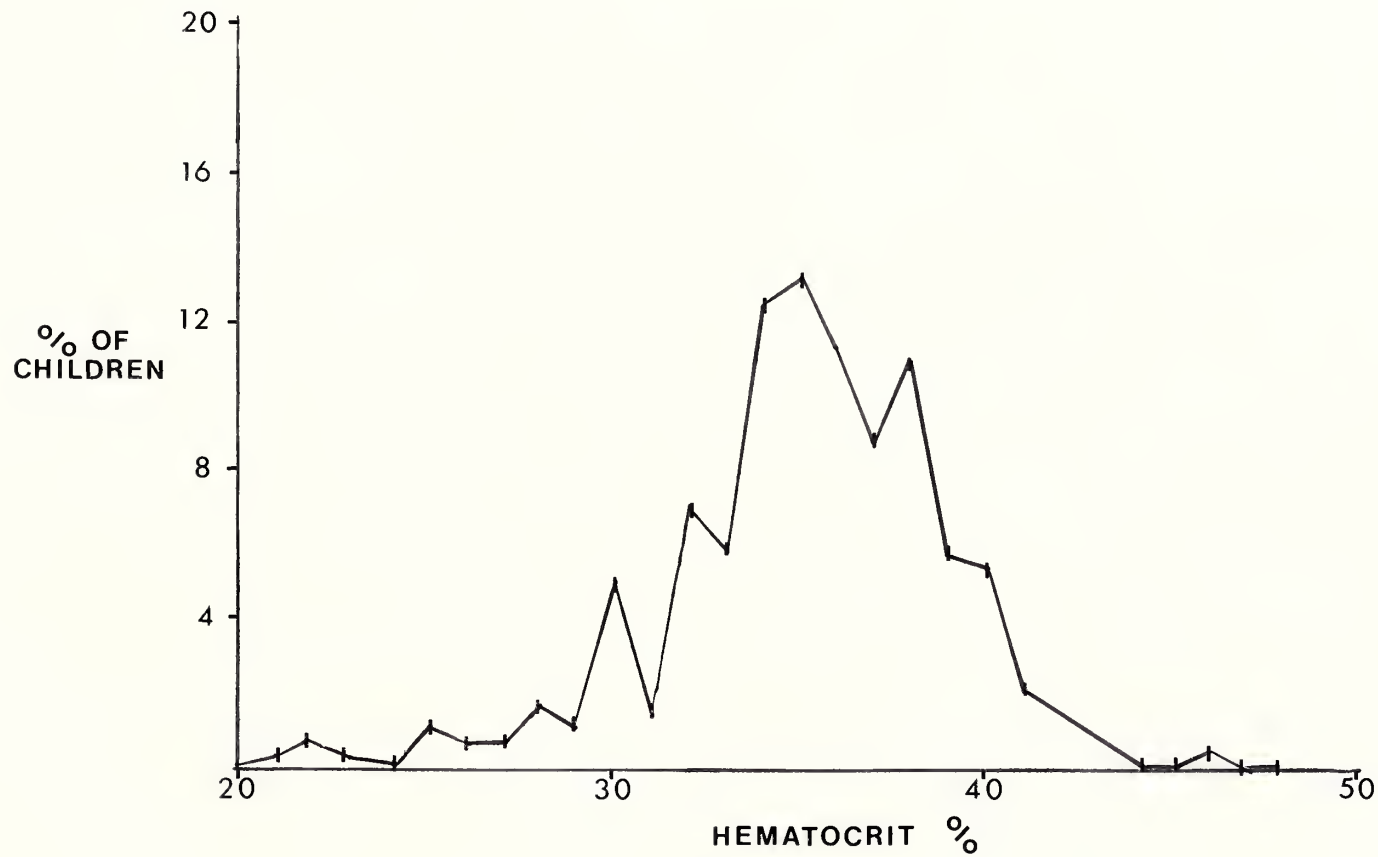


FIG.5 DISTRIBUTION OF HEMOGLOBINS IN 912 CHILDREN - h.h.c.
AGE 3-10 yrs.

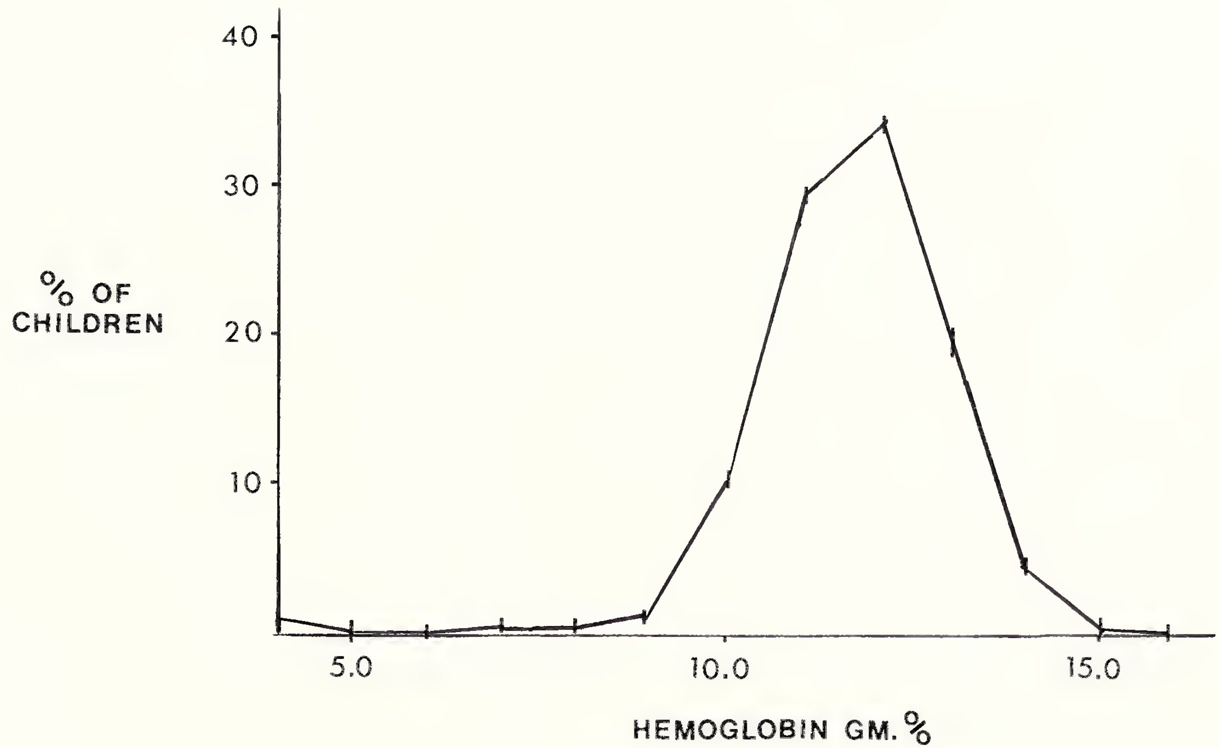


FIG. 6 DISTRIBUTION OF HEMATOCRITS IN 880 CHILDREN - h.h.c.
AGE 3-10 yrs.

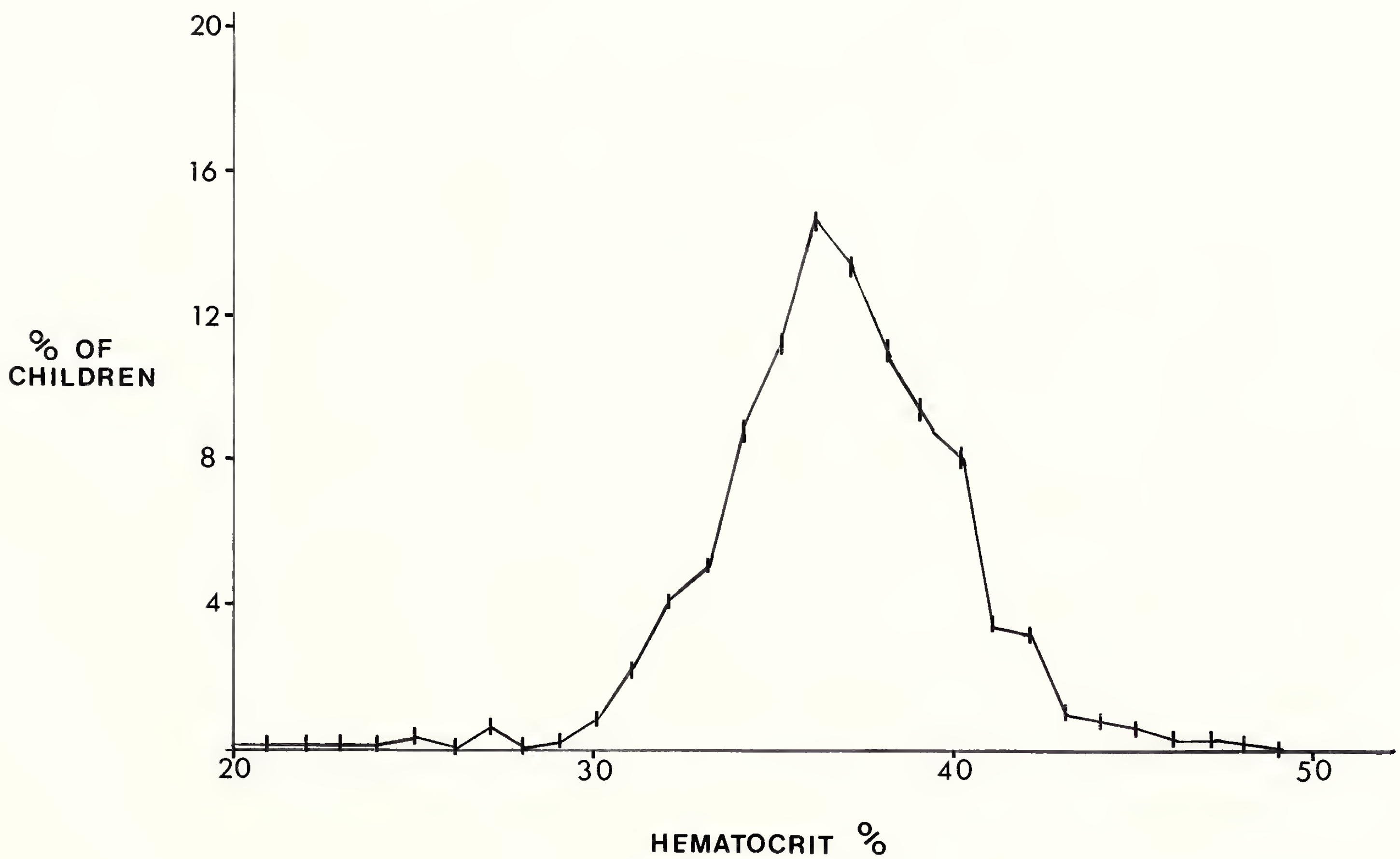


FIG. 7 DISTRIBUTION OF HEMOGLOBINS IN 305 CHILDREN - h.h.c.
AGE 10-14 yrs.

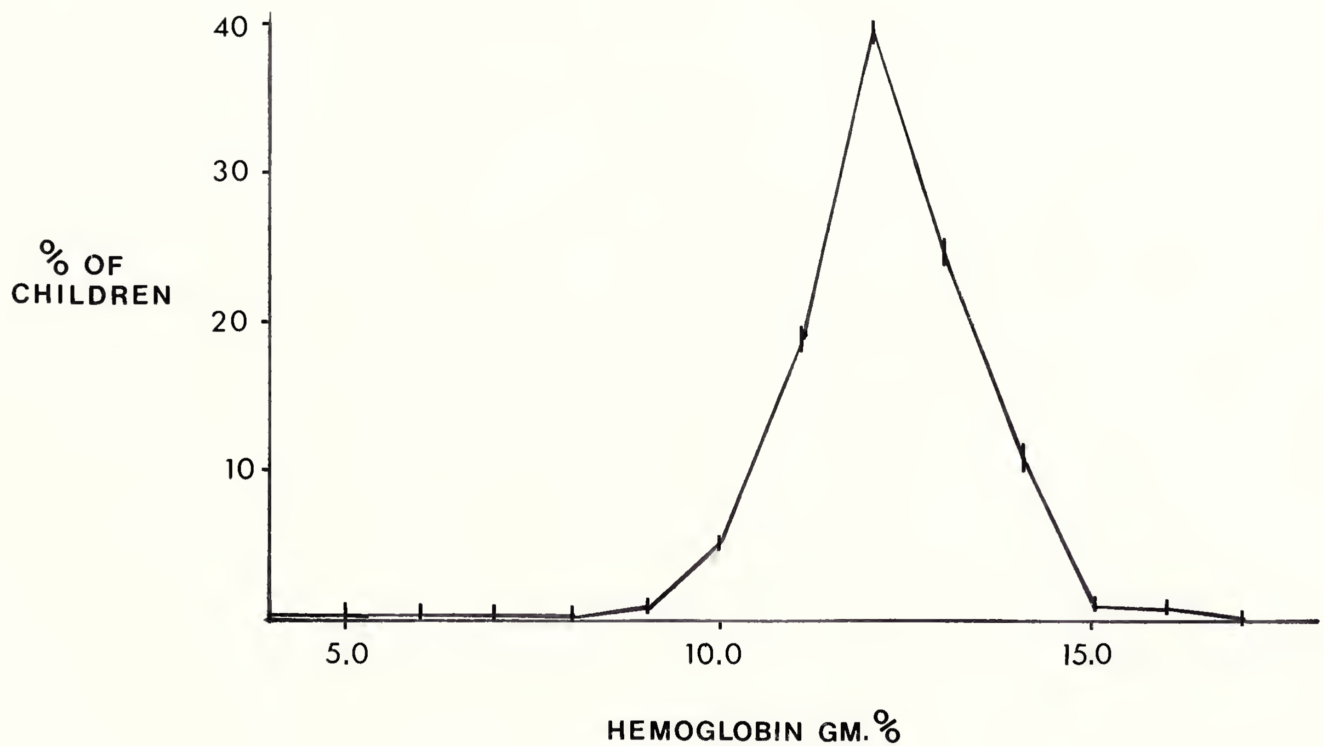


FIG. 8 DISTRIBUTION OF HEMATOCRITS IN 297 CHILDREN – h.h.c.
AGE 10-14 yrs.

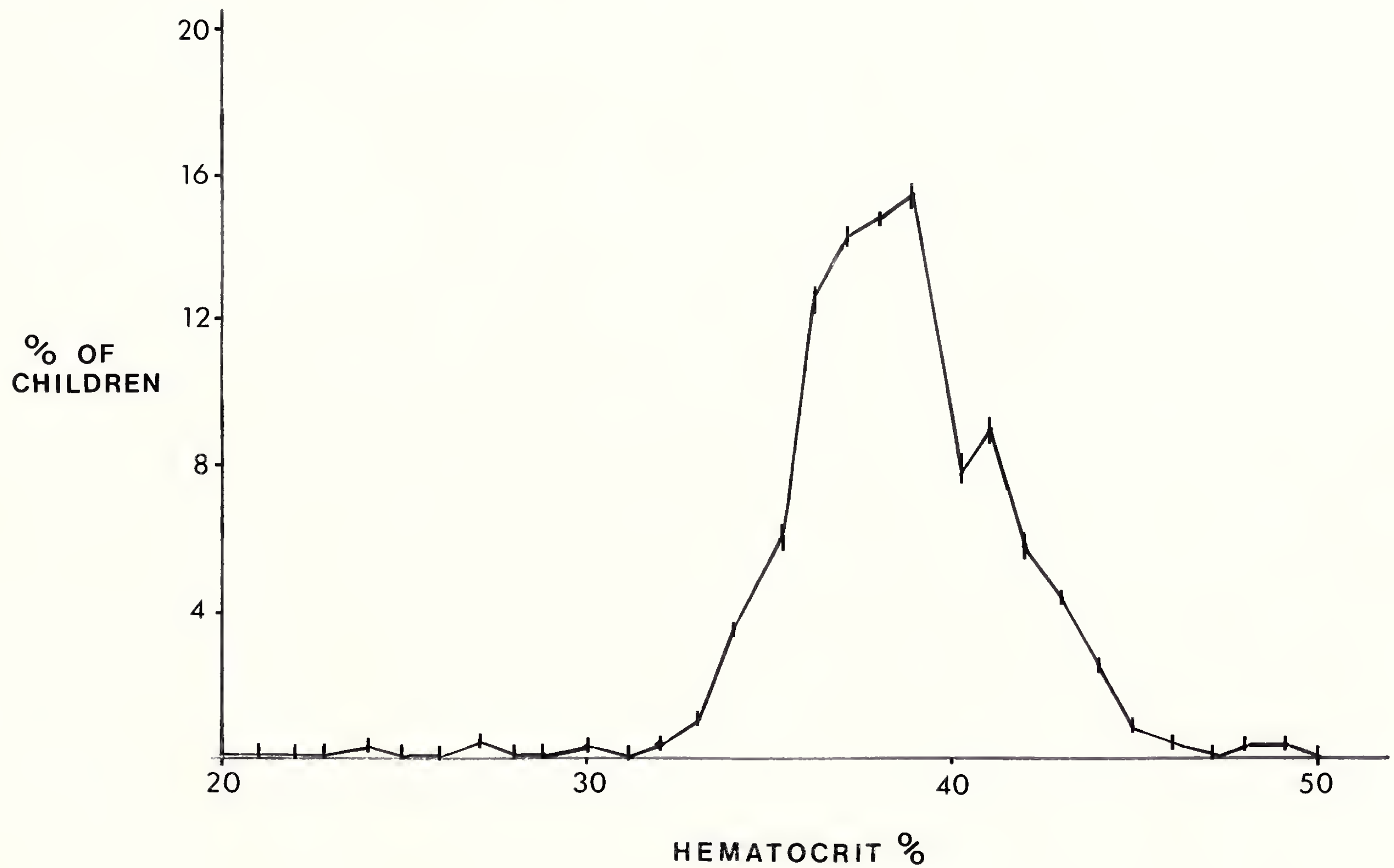


FIG. 9 DISTRIBUTION OF HEMOGLOBINS IN 81 MALES & 150 FEMALES - h.h.c.

AGE 14-21 yrs.

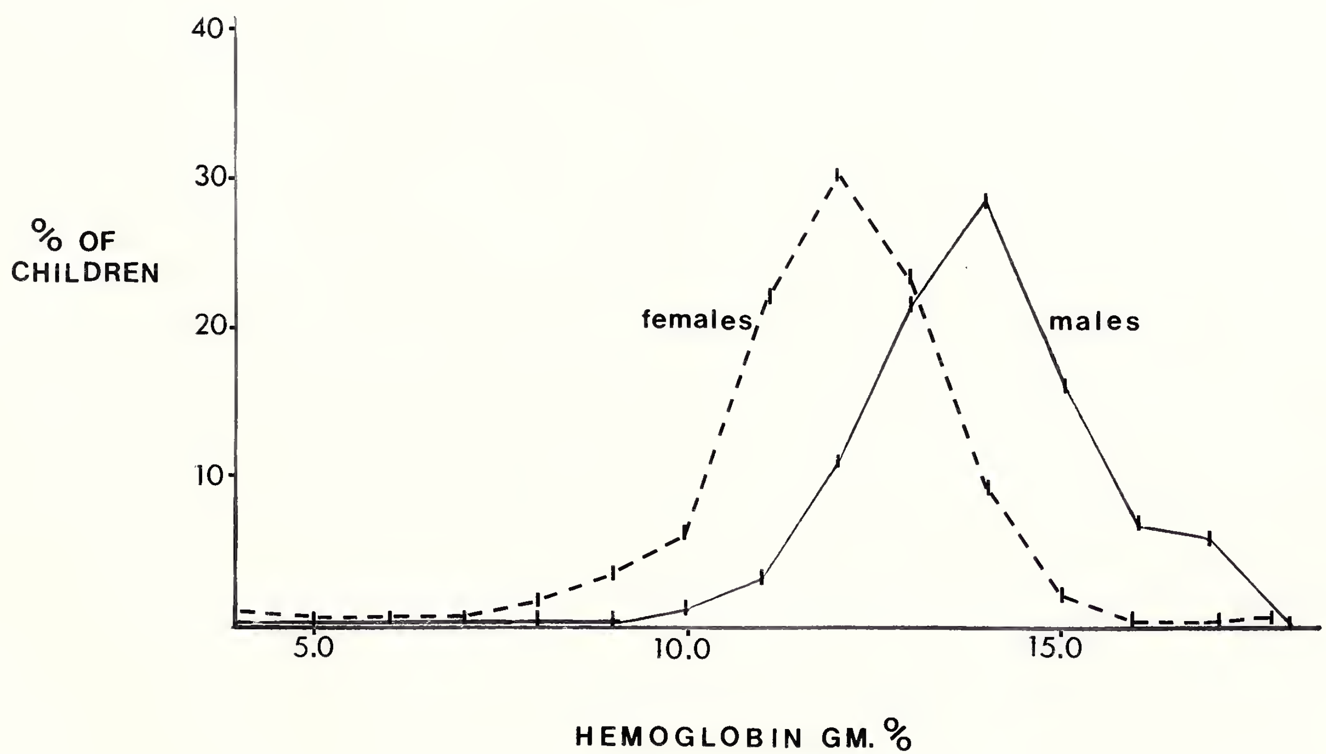
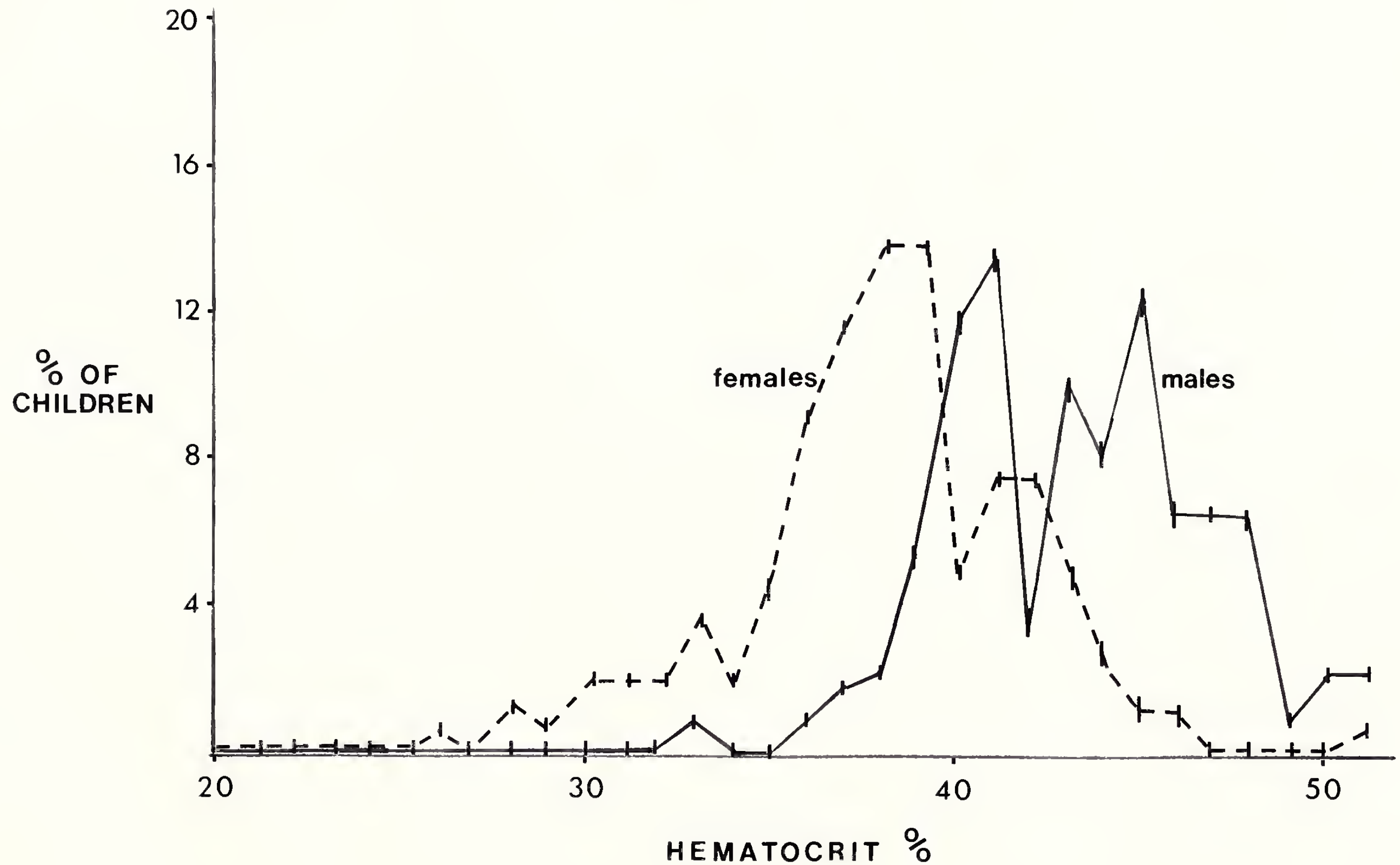


FIG. 10 DISTRIBUTION OF HEMATOCRITS IN 82 MALES & 159 FEMALES–h.h.c.

AGE 14-21 yrs.



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