East African Medical Journal Vol. 68 No. 6 June 1991
HAEMATOCRIT LEVELS AND ANAEMIA IN ETHIOPIAN CHILDREN
Z.A. Zein, B.Sc., M.P.H., Dr. med., Associate Professor, Department of Community Health, Gondar College of Medical Sciences, P.O. Box 196, Gondar, Ethiopia.

Address for correspondence: c/o Office of the Academic Vice President, Adddis Ababa University, P.O. Box 1176, Addis Ababa, Ethiopia.

HAEMATOCRIT LEVELS AND ANAEMIA IN ETHIOPIAN CHILDREN

Z.A. ZEIN

SUMMARY

The paucity of data on the haematological profile of Ethiopian children prompted this survey. In October and November, 1987, a survey of haematocrit levels utilizing capillary blood and morphological studies on blood films by means of the Wright stain was conducted in the peri-urban community of Koladiba in Northwestern Ethiopia. All but 21 children(0.5–6 years) in the community participated. The mean and median haematocrit levels in children 0.5–6 years was 38% each with a range of 26–52%. Lowest haematocrit was found between 1–2 years of age. The 3rd and 97th percentile values were 31–45% and identical with the mean ± 2 S.D. values. On a third of the children (251), blood film studies were done and 20% had microcytic hypochromic red blood cells. When an altitude corrected cut-off point of 38% was employed to define anaemia, the prevalence rate was 47.2%, the highest rate (60%) in children 1–2 years. However, use of a cut-off point based on the third percentile or ± 2 SD (31%), resulted in an underestimation of anaemia rates by 40%. The findings of this study are consistent with previous resports on anaemia rates and haematocrit levels in Ethiopian children residing in a similar environment. Although the iron content of the Ethiopian diet is one of the highest in the world, nutritional anaemia is a public health problem. Intervention measures using iron supplementation and nutrition education through existing primary health care network are recommended.

INTRODUCTION

About half of children in Africa are reported to be anaemic with the highest average prevalence rates found in eastern Africa(1). The health and socio-economic consequences of anaemia in children include fatigue and low work output, impairment of intellectual and physical development and resistance to common infections. In spite of this recognition, anaemia in children continues to be one of the major nutritional problems. A recent review(2) on anaemia in Africa not only lamented the neglect of the problem in the region, but also classified Ethiopia among several African countries for which data on childhood anaemia is either absent or unknown. A search of the literature indicated that over the past 30 years haematological studies in Ethiopia have been conducted with the aims of characterizing the intake

of iron and its bioavailability in
ment of reference values for
identification of risk groups for
studies it has emerged that Et
highest daily intake of dietary
day) iron in the world(4). As
the fact that the majority of
lands, anaemia is reported to
country, for instance pregnant

In comparison to a adults,
zation in Ethiopia is scanty. T
on the levels of haematocrit
0.5–6 years of age in atypical E

MATER

The cross-sectional community surve
was part of a project on child nutrit
Gondar College of Medical Sciences
periurban community of Koladiba si
at an altitude of 2000 meters above
ment operated health center which
sanitation services. Intestinal helmint
diarrhoeal diseases, and upper respira
At the time of the survey the pop
socio-demographic household survey
in October. All interviews and labo
under the supervision of the author.
lies was 60 Birr per month (1 Birr =
households and the majority (95%) o
a nearby river. The median per capit
diet consisted of "injera," a flat b
cereal and lentil sauce. Animal prote
days,

Initially, 840 children upto six
was considered for analysis. This
months of age due to the well know
refusal of some parents to participate
gical stool examination on these chil
for hookworm, trichuris and ascaris
excluded since the average intensity
of faeces each for hookworm and trich

As haemoglobinopathies have no
made to screen them. Packed cell vol
tocrit tubes with blood from free flo
in plasticine. Within two hours the t
and read immediately on a microhem
were also made on every third child
blood parasites and studying red blood

ine 1991

N ETHIOPIAN CHILDREN
ate Professor, Department of Community
.O. Box 196, Gondar, Ethiopia.

ie Academic Vice President, Adddis Ababa
opia.

EMIA IN ETHIOPIAN CHILDREN

ARY

ogical profile of Ethiopian children
ovember, 1987, a survey of haemato-
norphological studies on blood films
icted in the peri-urban community of
but 21 children(0.5–6 years) in the
median haematocrit levels in children
of 26–52%. Lowest haematocrit was
3rd and 97th percentile values were
: 2 S.D. values. On a third of the
lone and 20% had microcytic hypo-
ude corrected cut-off point of 38%
evalence rate was 47.2%, the highest
ver, use of a cut-off point based on
ulted in an underestimation of anae-
udy are consistent with previous res-
levels in Ethiopian children residing
on content of the Ethiopian diet is
al anaemia is a public health prob-
pplementation and nutrition educa-
network are recommended.

CTION

rted to be anaemic with the highest
n Africa(1). The health and socio-
children include fatigue and low
al and physical development and
ite of this recognition, anaemia in
jor nutritional problems. A recent
amented the neglect of the problem
ia among several African countries
ither absent or unknown. A search
ast 30 years haematological studies
e aims of characterizing the intake

of iron and its bioavailability in Ethiopians and their diet(3–6), the establishment of reference values for red blood cell parameters(3, 4, 7, 8) and the identification of risk groups for nutritional anaemia(3, 4, 7 – 12). From these studies it has emerged that Ethiopia may represent the country with the highest daily intake of dietary (for adults in the order of 300–500mg per day) iron in the world(4). As well as the high dietary intakes of iron and the fact that the majority of the Ethiopian population resides in the highlands, anaemia is reported to be rare in certain population groups in this country, for instance pregnant women(9–11).

In comparison to a adults, data on childhood haematological characterization in Ethiopia is scanty. The aim of this study was therefore to report on the levels of haematocrit and rates of anaemia in Ethiopian children 0.5–6 years of age in atypical Ethiopian highland community.

MATERIALS AND METHODS

The cross-sectional community survey conducted between October and November, 1987 was part of a project on child nutrition by the department of community health of the Gondar College of Medical Sciences in Northwestern Ethiopia. The study site is the periurban community of Koladiba situated 30 km from the regional capital, Gondar and at an altitude of 2000 meters above sea level. Since 1957 Koladiba is served by a government operated health center which provides outpatient, maternal and child health and sanitation services. Intestinal helminthiasis, Protein energy malnutrition, endemic goitre, diarrhoeal diseases, and upper respiratory tract infections are common health problems. At the time of the survey the population of Koladiba was 7000 inhabitants(13). A socio-demographic household survey in preparation for the present study was carried out in October. All interviews and laboratory work was done by senior medical students under the supervision of the author. Accordingly, the median monthly income of families was 60 Birr per month (1 Birr =U.S.$ 0.40). Latrines were available in 30% of the households and the majority (95%) of families obtained water from unprotected source, a nearby river. The median per capita water consumption was 6 litres a day. The staple diet consisted of "injera," a flat bread made from tef *(Eragrostis tef)*, the iron-rich cereal and lentil sauce. Animal proteins are rarely consumed except during major holidays,

Initially, 840 children upto six years of age were identified. Of these, data on 756 was considered for analysis. This was because of exclusion of all children under 6 months of age due to the well known physiological changes in blood parameters and refusal of some parents to participate in the study in the case of 21 children. Parasitological stool examination on these children revealed prevalence rates of 4%, 9% and 23% for hookworm, trichuris and ascaris infestations respectively. These children were not excluded since the average intensity of the infections was less than 40 eggs per gram of faeces each for hookworm and trichuris and 800 for ascaris.

As haemoglobinopathies have not so far been reported in Ethiopians, no effort was made to screen them. Packed cell volume (PCV) was determined by filling microhaematocrit tubes with blood from free flow finger or heel-pricks. The tubes were then sealed in plasticine. Within two hours the tubes were centrifuged at 12,000 rpm for 5 minutes and read immediately on a microhematocrit reading scale. Thin and thick blood smears were also made on every third child (a total of 251) using the wright stain to idetify blood parasites and studying red blood cell morphology.

Data were analyzed on a microcomputer using the SPSS software (SPSS Inc. Chicago). The analysis of variance (F–test) and the Z–test were used to compare means and the Chi-square test for comparison of proportions.

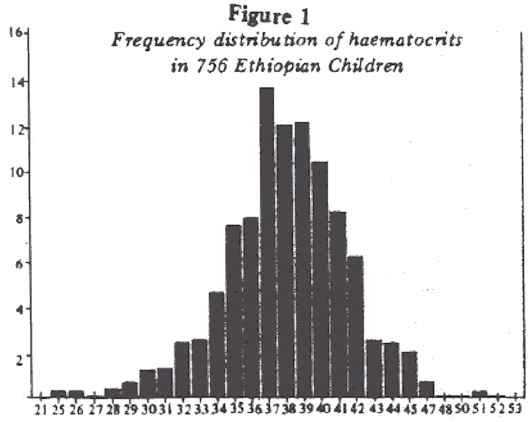
For the purpose of this study the cut-off points of hematocrit levels used to define anaemia are in accordance with the recommendations of the World Health Organization(14). Thus, in children 0.5–6 years the suggested cut-off point for pcv is 35% at sea level. In this report a cut-off point of 38% is used to correct for altitude by increasing pcv values by 4% for each 1000 meters of altitude as suggested by Hurtado(15).

RESULTS

Age distribution of study population: Of the 756 children, there were 357(47.2%) males and 399(52.8%) females. The difference between the percentages is not significant statistically (Chi–square = 10.5; $p > 0.05$). The age distribution of the study children is presented in Table 1. In the age group under one year, there were only 47 children mainly on account of exclusion of infants below six months. There were relatively more uniform representation of children above 1 year of age.

Haematological findings: The frequency distribution of pcv values are presented in Figure 1. Haematocrit values are negatively skewed. But, the mean and median values for the entire study population were 38.0% and identical. Therefore, an approximately symmetrical distribution was assumed. The range of haematocrit values was 26–52%. The variation of mean pcv values with age are shown in Table(1). There is a decline of pcv values from 37.3% to 36.5% in children 6–11 months and 12–23 months respectively, but were maintained at about 38% between 2 and 6 years. As borne out by the analysis of variance the difference in mean pcv values between the age groups is statistically significant ($F = 6.58$; $P < 0.01$). No linear trend of mean pcv values with increasing age was suggested by the F–test for deviation from linearity ($F = 3.23$; $P < 0.01$).

Figure 1
Frequency distribution of haematocrits in 756 Ethiopian Children



Age and sex

Age (Months)	No.
6 – 11	47
12 – 23	119
24 – 35	147
36 – 47	155
48 – 59	149
60 – 71	139
Total	756

* Figures in bracke are ± 1 stand

** Difference in mean PCV betv $P < 0.01$

In Table 2 are presented F lar to the mean values (Table in the age groups 12–23 mo values are equivalent to the encompass 95% of the observat

Age	PCV (%)
6 – 11	30.6 – 43.9
12 – 23	28.6 – 44.4
24 – 35	31.0 – 45.4
36 – 47	32.0 – 45.2
48 – 59	32.1 – 44.5
60 – 71	27.6 – 49.6
All	

ıter using the SPSS software (SPSS Inc. nd the Z–test were used to compare means portions.

f points of hematocrit levels used to define ıendations of the World Health Organiza- suggested cut-off point for pcv is 35% at % is used to correct for altitude by increas- ltitude as suggested by Hurtado(15).

TS

Of the 756 children, there were nales. The difference between the lly (Chi–square = 10.5; $p > 0.05$). en is presented in Table 1. In the age 47 children mainly on account of There were relatively more uniform f age.

distribution of pcv values are presen- negatively skewed. But, the mean opulation were 38.0% and identical. al distribution was assumed. The 6. The variation of mean pcv values s a decline of pcv values from 37.3% 2–23 months respectively, but were 6 years. As borne out by the analy- cv values between the age groups is .01). No linear trend of mean pcv by the F–test for deviation from

n of haematocrits
n Children

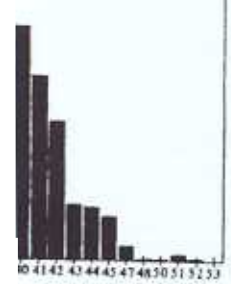


Table 1

Age and sex distribution of study population

Age (Months)	No.	%	PCV% (Mean ± 1 S.D)
6 – 11	47	6.2	37.3 (3.32)*
12 – 23	119	15.7	36.5 (3.97)
24 – 35	147	19.5	38.2 (3.58)
36 – 47	155	20.5	38.6 (3.30)
48 – 59	149	19.7	38.3 (3.10)
60 – 71	139	18.4	38.6 (5.52)
Total	756	100.00	38.0 (3.48)

* Figures in bracke are ± 1 standard deviation

** Difference in mean PCV between age groups is statistically significant $F = 6.58$; $P < 0.01$

In Table 2 are presented PCV percentile and mean ± 2 S.D. values. Similar to the mean values (Table 1), the 3rd percentile values are relatively low in the age groups 12–23 months. The upper(97) and lower(3) percentile values are equivalent to the corresponding values of mean ± 2 S.D which encompass 95% of the observations for the entire population.

Table 2

PCV percentile values

Age	PCV (%)	Percentile PCV values				
(Months)	Mean ± 2 S.D	3	10	50	90	97
6 – 11	30.6 – 43.9	30	31	37	42	43
12 – 23	28.6 – 44.4	29	32	37	41	45
24 – 35	31.0 – 45.4	30	34	38	43	45
36 – 47	32.0 – 45.2	31	35	39	43	45
48 – 59	32.1 – 44.5	32	34	38	43	45
60 – 71	27.6 – 49.6	30	34	39	42	45
All	31.0 – 45.0	31	34	38	42	45

Prevalence of anaemia: Age-specific anaemia prevalence rates using the WHO cut-off points corrected for altitude (pcv < 38%) and a cut-off point of pcv < 31% based on − 2 S.D. values from the mean are presented in Table 3. The latter cut-off point is also equivalent to the 3rd percentile values. Using a lower limit of haematocrit (38%), the overall prevalence anaemia rate in the entire study population was 42.7%. Again the highest prevalence rate of anaemia (60%) was observed during the second year of age, and the lowest rate in 6 year–old children. The prevalence rate of anaemia in children under 3 years of age was 60%. From the second year of age onwards however, there appears to be declining age-specific prevalence rates of anaemia.

The use of −2 S.D or the 3rd percentile cut-off points in this study generally produced similar results in the identification of at-risk age groups and the decline of anaemia rates with progression of age, but grossly underestimated the overall anaemia rate by about 40%. Use of a cut-off point of < 31% resulted in an overall prevalence rate of 2.6% only.

Of the 251 children on whom blood smears were obtained, 61 (20%) were found to have microcytic hypochromic red blood cells suggesting iron deficiency. The rest had normocytic normochromic blood films. Haemoparasites were not encountered.

Table 3:
Prevalence rates of anaemia

Age (Month	PCV < 38% No (N = 756)	%	PCV < 31% No (N = 756)	%
6 – 11	24	51.1	2	4.2
12 – 23	72	60.5	7	5.9
24 – 35	60	40.8	4	2.7
36 – 47	58	37.4	2	1.3
48 – 59	62	41.6	1	0.7
60 – 71	47	33.8	4	2.9
All	323	42.7	20	2.6

DISCUSSION

The study population is representative of the majority of Ethiopian children in whom protein energy malnutrition and intestinal parasitism are widely prevalant. Stringiest selection criteria in the exclusion of possibly pathologic children were not used here as often is the case in studies concerned with establishing reference values which must seek to identify as healthy study subjects as could be possible. The reason are many and were concerned with the objectives of the study, pragmatism, limited resources, difficulties in

conducting more comperehensive
from the difficulties encounter
For example, the seminal haemato
in an attempt to select healthy cl
and attended by children from
parasitism and elevated ESR in
However, as the determination of
logical purposes has been popul
Ethiopian children is still meagre,
feature the problem of childhood

Furthermore, because of the c
values, it is recommended(15) fro
lay down minimal acceptable stan
red anaemic taking into account t
able as well as other health needs o

The mean pcv values in thi
reported pcv values of 42 and
1–4 and 5–9 years respectively
Addis Ababa, the capital city. Su
only by 10% (90th percentile) of
and are probably more compatibl
Dallman and Siimes(16) for Americ

With regard to differences i
children in Africa, similar observat
by Gilles(15)] when he found that
had lower haemotocrit, "elites" ch
mean and standard deviations ident

The study of Hofvander(4) w
metres) and chosen to represent
would probably provide a better co

In Ijaji, the mean pcv values i
years were 36.7% and 37.9% resp
corresponding pcv value was 38.2
shed data with our results was mad
in Ijaji and Koladiba are not signi
an identical methodology in a stu
nities in the Gondar region in No
pcv value of 37.9% with a mean
0.5 to 5 years, identical to the resul

For comparison purposes data
milieu and countries are scanty. Gill
globin and haematocrit values in cl
three Southeast Asian countries. M

emia prevalence rates using the WHO
cv < 38%) and a cut-off point of
n the mean are presented in Table 3.
t to the 3rd percentile values. Using
verall prevalence anaemia rate in the
gain the highest prevalence rate of
second year of age, and the lowest
alence rate of anaemia in children
econd year of age onwards however,
prevalence rates of anaemia.
centile cut-off points in this study
identification of at-risk age groups
ression of age, but grossly underesti-
ut 40%. Use of a cut-off point of
te of 2.6% only.
d smears were obtained, 61 (20%)
omic red blood cells suggesting iron
ochromic blood films. Haemopara-

of anaemia

	PCV <31%	
	No (N = 756)	%
	2	4.2
	7	5.9
	4	2.7
	2	1.3
	1	0.7
	4	2.9
	20	2.6

ON

the majority of Ethiopian children
ad intestinal parasitism are widely
ne exclusion of possibly pathologic
the case in studies concerned with
seek to identify as healthy study
are many and were concerned with
, limited resources, difficulties in

conducting more comperehensive blood tests and above all the lessons learnt from the difficulties encountered by previous investigators in Ethiopia. For example, the seminal haematological work in this country by Hofvander(4) in an attempt to select healthy children from the best school in the country and attended by children from privileged families encountered intestinal parasitism and elevated ESR in the supposedly healthy reference children. However, as the determination of haematocrit or haemoglobin for epidemiological purposes has been popular and data on haemotological profiles of Ethiopian children is still meagre, the findings of this study are expected to feature the problem of childhood anaemia in Ethiopia.

Furthermore, because of the complexity involved in establishing "normal" values, it is recommended(15) from a practical approach for each country to lay down minimal acceptable standards below which an individual is considered anaemic taking into account the financial and manpower resources available as well as other health needs of the country.

The mean pcv values in this study was 38%. In 1968 Hofvander(4) reported pcv values of 42 and 43.8% in "elite" Ethiopian children aged 1–4 and 5–9 years respectively and living at an altitude of 2400 metres in Addis Ababa, the capital city. Such high values of haematocrit are attained only by 10% (90th percentile) of Koladiba children in comparable age-group and are probably more compatible with haematological values reported by Dallman and Siimes(16) for American children.

With regard to differences in haematocrit between 'elite' and village children in Africa, similar observations were also noted by Akingube [quoted by Gilles(15)] when he found that while groups of village and hospital children had lower haemotocrit, "elites" children from families of University staff had mean and standard deviations identical to those given by Wintrobe(17).

The study of Hofvander(4) was also carried out in Ijaji (altitude 1850 metres) and chosen to represent atypical Ethiopian highland community would probably provide a better comparison for this study.

In Ijaji, the mean pcv values in infants 6–11 months, and children 1–4 years were 36.7% and 37.9% respectively. Among children 5–9 years, the corresponding pcv value was 38.2%. A statistical comparison of Ijaji published data with our results was made. Using the Z–test, the mean pcv values in Ijaji and Koladiba are not significantly different. This author (12) using an identical methodology in a study of haematocrit values in eight communities in the Gondar region in Northwestern Ethiopia has reported a mean pcv value of 37.9% with a mean ± 2 S.D range of 26.1–49.7% in children 0.5 to 5 years, identical to the results found in the present study (Table 1).

For comparison purposes data on normal haematological values in similar milieu and countries are scanty. Gilles(15) has reviewed and presented haemoglobin and haematocrit values in children 0.5 to 5 years for two African and three Southeast Asian countries. Mean pcv values were lower than the values

found in this study and generally between 31 and 36%.

From the statistical point of view, the reference range suggested by our data is 31 – 45%. However, Dallman and Siimes(16) have recommended the consideration of the 10th percentile as a lower limit for suspecting iron deficiency in populations in which iron deficiency is common. In our study this value would be 34%.

The prevalence rate of anaemia using altitude adjusted WHO criteria in the entire study group was 42.7% and in children below 3 years 60%, the highest vulnerable group being children between 1–2 years. The latter age-group has the lowest mean pcv values. The haematological survey in the same region, reported an overall prevalence rate of 37.6%(12). Hofvanders' anaemia rate for Ijaji children again are consistent with the findings of this study. In his series the anaemia rates in infants 6 – 11 months, children 1 – 4 and 5–9 years is 80, 48.1 and 68.6% respectively and the rates in "elite" children were considerably low (< 4%). The use of lower cut-off points in this study has resulted in an underestimation of the anaemia rate. Even if the suggestion to use the 10th percentile(16) were used, the anaemia rate would be 9%. A prevalence rate of 20% of microcytic anaemia obtained in the study of blood films suggests that the estimated rate of anaemia based on WHO altitude adjusted criteria are more realistic.

An iron supplementation trial in our study community would probably reveal that the true rate of iron deficiency anaemia in children may even be higher than that implied by this study.

In contrast to the shortage of data on normal haematological values in the tropics in general and Africa in particular, survey results on childhood anaemia are available for at least 26 countries(1), with an average prevalence rate for the continents' under five children estimated at 59% with a range of 15 – 93%. Also, the highest average prevalence rates of anaemia (74%) are found in Eastern Africa(1) to which Ethiopia also belongs.

The aetiology of childhood anaemia are multiple and complex. In the context of this study iron deficiency may be an important factor. The high dietary intake of iron of the general Ethiopian population may not be shared by children until after 3 years of age when they start participating in the adult iron rich foods(4). In this region partial breast-feeding is continued until the child is 4 years and supplementary feedings are started late(18). Numerous "fasting" days (110–150 per year) observed by coptic Christians(19) in our study area must contribute to nutritional anaemia by restricting the eating of animal protein as are low levels of energy intake and intestinal parasites. The only practical approach to the prevention and treatment of iron deficiency anaemia consists in iron supplementation(1), and nutrition education perhaps as part of primary health care activities. However, the difficulties of large scale supplementation programmes should not be underestimated.

A

To the senior medical students of t in the field work and to the Cath support.

1. De Maeyer, E. and Adiels-Teg *Wld. Hlth. Stat. Quart.* **38**:302
2. WHO(AFRO). Anaemia in the
3. Interdepartmental Committee Nutrition Survey, Ministry of E
4. Hofvander, Y. Hematological a high iron intake. *Acta. Med.*
5. Mengesha, H–M. Chemical cc wheat, barley and grain sorghur
6. Besrat, A., Admasu, A. and C (Eragrostis tef), *Ethiop. med.*
7. Jaeger, O.A. Data on school he 133, 1959.
8. Abdulkadir, J., Bolodia, G., T Haemoglobin and haematocrit *Ethiop. med. J.* 16: 5, 1978.
9. Peters, W. H. Hematocrit and and non-pregnant females in Nc
10. Ross, S.M. Haemoglobin and I intake and living at high altitud
11. Gebre-Medhin, M., Killander, in pregnancy in Ethiopia. *Scan*
12. Zein A.Z. and Mekonnen, A. living at different altitudes in Nc
13. Central Statistical Authority. strative regions, awrajas and tv Ababa, 1989. 14. World Hea Report Series, No. 503. Geneva
14. Hurtado, A., Marino, C., and I topoetic activity. *Arch. intern.*
15. Gilles, H.M. Normal Haematol 697, 1981.
16. Dallman, P.R. and Siimes, M.. volume in infancy and childhoo
17. Wintrobe, M.M. *Haematology*, 6
18. Knutsson, K–E and Valquist, on a joint attack on nutritional 376, 1968.
19. Mekonnen, A., and Zein, A.Z. I ratives in Gondar region, Ethiop

n 31 and 36%.
the reference range suggested by our
d Siimes(16) have recommended the
a lower limit for suspecting iron defi-
iciency is common. In our study this

ng altitude adjusted WHO criteria in
in children below 3 years 60%, the
between 1–2 years. The latter age-
The haematological survey in the
nce rate of 37.6%(12). Hofvanders'
consistent with the findings of this
ıfants 6 – 11 months, children 1 – 4
espectively and the rates in "elite"
The use of lower cut-off points in
nation of the anaemia rate. Even if
ile(16) were used, the anaemia rate
of microcytic anaemia obtained in
e estimated rate of anaemia based on
ealistic.
r study community would probably
y anaemia in children may even be

on normal haematological values in
ticular, survey results on childhood
ntries(1), with an average prevalence
en estimated at 59% with a range of
valence rates of anaemia (74%) are
pia also belongs.
are multiple and complex. In the
y be an important factor. The high
opian population may not be shared
hen they start participating in the
partial breast-feeding is continued
ntary feedings are started late(18).
r year) observed by coptic Christi-
e to nutritional anaemia by restrict-
w levels of energy intake and intesti-
ch to the prevention and treatment
n supplementation(1), and nutrition
alth care activities. However, the
n programmes should not be unde-

Acknowledgements

To the senior medical students of the Gondar College of Medical Science for assistance in the field work and to the Catholic Relief Service (Ethiopia) for providing financial support.

REFERENCES

1. De Maeyer, E. and Adiels-Tegman, M. The prevalence of anaemia in the World. *Wld. Hlth. Stat. Quart.* **38**:302, 1985.
2. WHO(AFRO). Anaemia in the African region. *Epidem. Bull.* **7**: 20. 1989.
3. Interdepartmental Committee on Nutrition for National Defence. Ethiopian Nutrition Survey, Ministry of Defense, Washington, D.C., 1959.
4. Hofvander, Y. Hematological investigations in Ethiopia, with special reference to a high iron intake. *Acta. Med. Scand. (Supple.).* **494**: 1. 1968.
5. Mengesha, H–M. Chemical composition of *(Eragrostis tef* compared with that of wheat, barley and grain sorghum *Econ. Botan.* **20**: 268, 1966.
6. Besrat, A., Admasu, A. and Ogbai, M. Critical study of the iron content of tef (Eragrostis tef), *Ethiop. med. J.* **18**: 45, 1979.
7. Jaeger, O.A. Data on school health services in Gondar, Ethiopia. *J. trop Paediat.* **4**: 133, 1959.
8. Abdulkadir, J., Bolodia, G., Tegegne, M., Fenta, M., Alemu, A., and Tesemma, D. Haemoglobin and haematocrit levels in young adult Ethiopian in Addis Ababa. *Ethiop. med. J.* **16**: 5, 1978.
9. Peters, W. H. Hematocrit and haemoglobin levels in adult males and in pregnant and non-pregnant females in Northern Ethiopia. *Ethiop. med. J.* **22**: 17, 1984.
10. Ross, S.M. Haemoglobin and hematocrit values in pregnant women in a high iron intake and living at high altitude. *J. Obstet. Gynaec. Brit Cwlth.* **79**: 1103, 1972.
11. Gebre-Medhin, M., Killander, A., Valquist, B. and Wuhib, E. Rarity of anaemia in pregnancy in Ethiopia. *Scand. J. Haemat.* **16**: 168, 1976.
12. Zein A.Z. and Mekonnen, A. The prevalence of anaemia among populations living at different altitudes in Northwestern Ethiopia. *Ethiop. med. J.* **25**: 105, 1987
13. Central Statistical Authority. Population estimates of autonomous and administrative regions, awrajas and twon Statistical Bulletin. No. 72. page 39. Addis Ababa, 1989. 14. World Health Organization. Nutritional anaemia. Technical Report Series, No. 503. Geneva, 1972.
14. Hurtado, A., Marino, C., and Delgado, E. Influence of anoxemia on the haematopoetic activity. *Arch. intern. Med.* **75**: 284, 1945.
15. Gilles, H.M. Normal Haematological values in tropical areas. *Clin. Haemat.* **10**: 697, 1981.
16. Dallman, P.R. and Siimes, M.A. Percentile curves for haemoglobin and red cell volume in infancy and childhood. *J. Pediat.*, **94**: *26, 1979.*
17. Wintrobe, M.M. *Haematology*. 6th edition, Lea and Febiger, Philadelpia, 1976.
18. Knutsson, K–E and Valquist, B. Medicine and social anthropology. Some notes on a joint attack on nutritional problems in Ethiopia. *Acta. Univ. Uppsalien*, **17**: 376, 1968.
19. Mekonnen, A., and Zein, A.Z. Health status in the new peasant producers' co-operatives in Gondar region, Ethiopia. *Ethiop. med. J:* **24**: 123, 1986.