

# Anemia in pregnancy in the highlands of Tanzania

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**Background.** Anemia in pregnancy is common in Tanzania, but many areas have not been investigated. This study describes prevalence and determinants of anemia among rural pregnant women living at 1300–2200 meters above sea level in Northern Tanzania.

**Methods.** Three thousand eight hundred and thirty-six pregnant women from two rural divisions of Mbulu and Hanang districts attending antenatal clinic between January 1995 and March 1996 were assessed in a cross-sectional study. Blood samples were examined for hemoglobin concentration (Hb) and thick blood slide (BS) for malaria. Information on date of examination, village, age, ethnic and religious affiliation, gestational age, and parity was recorded. Altitude was derived from official maps. Main outcome measures were mean Hb level and risk of anemia defined as a Hb of less than 9.0 g/dl.

**Results.** Hb levels ranged from 4.5 to 18.1 g/dl, and mean was 12.1 g/dl. Twenty-three per cent had a Hb of less than 11 g/dl, 4.6% less than 9 g/dl and 0.5% less than 7 g/dl; standardized to sea level 36.1%, 8.8%, and 1.1%, respectively. The mean Hb increased by 0.3 g/dl per 200 m increased altitude, and the risk of anemia decreased with a factor of 0.6 per 200 m increased altitude. We found higher risk of anemia at higher maternal age (1.2 times increased risk per 5 years). Furthermore, the Datoga tribe had twice the risk of anemia compared with the Iraqw. The risk of anemia was only half at 3–4 months of gestation compared to at 7–8 months. The risk increased six-fold in the rainy season of 1995, and the risk was almost double among those with malaria parasitemia.

**Conclusions.** Anemia in pregnancy was common in this area of high altitude in rural Tanzania, but less prevalent than indicated by studies from most other parts of the country. The study confirms that preventing anemia is a challenge in preventive antenatal care in the highlands of Tanzania. Studies focussing on the specific etiologic agents are needed.

**Key words:** anemia; hemoglobin; pregnancy; Tanzania

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Anemia in pregnancy is regarded as a major risk factor for an unfavorable outcome of pregnancy. It has been associated with premature labor (1), low birth weight (2, 3), and maternal (4) and perinatal mortality (6), but some of these associations are not firmly established (7, 8). According to the

World Health Organization (WHO), anemia in pregnancy is defined as hemoglobin concentration (Hb) less than 11.0 g/dl, and severe anemia as Hb less than 7.0 g/dl (9). Many authors have advocated the use of trimester specific cut-off points for anemia (10, 11). Research on anemia has been encouraged.

The prevalence of anemia in pregnancy shows great variations in different parts of the world. Studies from industrialized countries show that 2–45% of pregnant women have a Hb less than 11,

#### Abbreviations:

ANC: antenatal clinic; Hb: hemoglobin; MCH: mother and child health; OR: odds ratio; WHO: World Health Organization.

whereas the prevalence is generally higher and the variation is greater in developing countries with 5–90% anemia (12).

At higher altitudes, hypoxia causes the Hb to increase, which may mask anemia. In order to avoid this problem, CDC recommends an altitude-corrected anemia cut-off (13). In some areas of high altitude, anemia in pregnancy was almost non-existent (14, 15). In other areas at high altitudes, the prevalence of anemia is high (16). Andean highlanders have higher Hb than Himalayan residents at similar altitude (17). The high altitude in itself does not protect from anemia.

Most published studies on anemia in pregnancy in Tanzania have demonstrated a prevalence of 41% to 95% (Hb less than 11.0 g/dl) (18–21). However, none of these studies were done at altitudes above 1500 meters above sea level, and large parts of Tanzania have not been investigated. Our objective was to assess the prevalence and determinants of anemia in pregnancy in a rural population in the highlands of Northern Tanzania.

## Material and methods

### *Study area*

The study was done in Mbulu and Hanang districts of Arusha region in Northern Tanzania. The two selected rural divisions Dongobesh and Basotu consisted of 42 villages. The area is situated in the Rift Valley system, the altitude ranging from 1300 to 2200 meters above sea level. Based on the 1988 census and an annual growth rate of 3.8%, the total population in the two selected divisions was around 143,000 in 1995. Estimated number of women aged 15–44 was 28,000. Estimated annual number of births was 6,000 based on an expected crude birth rate of 41.9 per 1000 (22). Some of the women in the study population lived in villages, others lived scattered in the countryside. The two main ethnic groups in the study area were the Iraqw and the Datoga; other tribes were represented in small numbers.

There were both governmental and non-governmental institutions providing health services in the area. Within the two selected divisions, there was one hospital, one health center, 14 dispensaries, and 16 stations with monthly ('mobile') mother- and child health (MCH) care services in 1995. At the start of our study, Haydom Lutheran Hospital was running 12 out of the 32 MCH clinics in this area.

### *Subjects*

We recorded 4,472 attendants at 12 antenatal clinics of Haydom Lutheran Hospital from Jan-

uary 1995 until March 1996. Of these, 68 were later proven to be not pregnant, and 568 did not have their Hb checked because of logistic problems in the mobile clinics on certain days. The remaining 3,836 were included for the analysis. Participants were estimated to represent 57% of all pregnant women from the two divisions during this period, based on census estimates of population size and an expected birth rate of 41.9 per 1000 (22).

### *Data collection*

The examinations and the data collection took place at 12 MCH clinics, the research team being an additional activity to the pre-existing antenatal services provided by Haydom Lutheran Hospital. We recruited field assistants who were fluent in the Iraqw and Datoga languages in addition to the official Swahili. Based on consent, the participants were interviewed and had blood drawn before they went through the usual antenatal service.

The following information was recorded: name, village, age, ethnic affiliation, religious affiliation, parity, and gestational age. The exact gestational age was difficult to obtain because many participants did not know the exact dates. However, the woman usually remembered well the number of months since she lost menstruation, and this was recorded as an approximation for gestation. Because of unexpected logistic problems, registration of ethnic and religious affiliation was not performed in the first phase of the study, which explains the high number of missing values on these variables.

A capillary blood test was taken for measuring the Hb, and a thick blood slide for detection of malaria parasites. For Hb measurements, we used two HemoCue<sup>®</sup> photometers (Ängelholm, Sweden). Thick blood slides were stained with Giemsa stain and examined by the most experienced laboratory assistants at the hospital. The results are based on blood drawn at the women's first attendance visit. The women had their first attendance at different stages of pregnancy, from one month to full term.

The study period covered the rainy season of 1995 (January-June 1995), dry season of 1995 (July-December 1995) and part of the rainy season of 1996 (January-March 1996). For analytic purposes we divided it into five three-month periods, January-March 1995, April-June 1995, July-September 1995, October-December 1995, and January-March 1996. The altitudes (given in meters above sea level) of the 42 villages included in the study were deducted from official maps of Tanzania with contour lines (23). The altitude at a village center was assigned to represent that village.

Table I. Mean Hb and fraction with anemia in relation to demographic characteristics among pregnant women in Mbulu and Hanang Districts, Tanzania, 1995–1996

Background variable	n <sup>a</sup>	Hemoglobin concentration		Adj. regr. coefficient <sup>b</sup>	Anemia (Hb < 9.0 g/dl)	
		mean	(95% CI)		%	Adjusted OR <sup>b</sup>
<b>Total</b>	3836	12.1	(12.1–12.2)		4.6%	
<b>Age</b>						
<=19	223	12.5	(12.2–12.7)	-0.11***	4.0%	1.17*
20–24	1088	12.2	(12.1–12.3)		4.2%	
25–29	886	12.1	(12.0–12.2)		4.6%	
30–34	557	11.9	(11.8–12.1)		5.2%	
35–39	288	11.9	(11.7–12.1)		4.9%	
40–49	99	11.9	(11.5–12.3)		11.1%	
<b>Altitude</b>						
<1600	86	11.2	(10.9–11.5)	0.29***	12.8%	0.62***
1600–1799	2605	12.1	(12.0–12.1)		5.0%	
1800–1999	1045	12.3	(12.2–12.3)		3.3%	
>=2000	100	12.7	(12.4–13.0)		1.0%	
<b>Tribe</b>						
Iraqw <sup>c</sup>	1681	12.1	(12.1–12.2)	–	5.1%	1.00
Datoga	287	11.7	(11.5–11.9)	-0.37**	9.1%	2.05*
Other	51	11.6	(12.0–12.1)	-0.10	3.9%	0.40
<b>Religion</b>						
Protestant <sup>c</sup>	982	12.0	(11.9–12.1)	–	6.3%	1.00
Catholic	518	12.3	(12.1–12.5)	0.28**	4.2%	0.63
Traditional	465	12.0	(11.8–12.1)	0.00	5.6%	0.73
Other	16	11.6	(10.5–12.7)	0.02	12.5%	5.89*

\* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$ .

<sup>a</sup> The variables have different numbers of missing values.

<sup>b</sup> Regression coefficients obtained in multiple regression analysis and odds ratios (OR) obtained in multiple logistic regression applies to 5-year intervals with age, and to 200 m intervals with altitude, and are adjusted for woman's age, duration of pregnancy, month of examination and altitude. Additional adjustment for religion in analysis of tribe and for tribe in analysis of religion. Age and altitude were entered as continuous variables. Adjusted regression coefficient represents the adjusted average difference in Hb (g/dl) between the given groups of the variables in the Table. Odds ratio was used as an approximation for relative risk.

<sup>c</sup> Reference category.

The subjects were informed about the test results of Hb immediately. Subjects with Hb below 10.0 g/dl were given free tablets of iron and folic acid for a month. Women with blood slide showing malaria parasitemia were given a standard therapeutic dose of Chloroquine tablets free of charge. Further management was taken care of by the MCH and women with severe anemia or malaria were referred to the hospital. No remuneration was given to participants.

### Statistical analysis

For data entry, we used the EpiInfo statistical package (version 6.04b), with repeated data entry for correction of errors (24). SPSS was used for statistic analysis (25). We performed multiple logistic regression analyses of determinants of anemia (Hb < 9.0 g/dl) with adjustment for gestational age, season, altitude and maternal age, and the odds ratios obtained were used as an approximation for relative risk. We aimed at adjusting

only for variables with consistent effects in the preliminary analyses. For analytical purposes, we defined anemia as Hb of less than 9.0 g/dl, since severe anemia was rare in this population. Multiple linear regression analyses of mean Hb levels were also used, with the same adjustments.

In the regression analyses, we entered age, parity and altitude as continuous variables. Although the association between Hb and altitude has been described to be exponential (17), an assumption on linearity is justifiable within our range of altitude.

For comparing the prevalence of anemia at higher altitudes with sea level, WHO and CDC advocates increasing the anemia cut-off point according to the altitude. Since we included women residing at varying altitudes, we standardized the Hb to sea level, on which we could apply the anemia cut-off. The adjustment formula was derived from Dirren et al.

$$(\text{Hb}_{\text{sea level}} = \text{Hb}_{\text{measured}} - (3.44 \times (e^{(0.000633 \times \text{altitude})} - 1))) \quad (17).$$

This standardized Hb was used only for comparing anemia prevalence with other studies, and was not used in the analysis of determinants of anemia.

All significance tests were two-tailed with a significance level of 0.05.

#### Ethical considerations

The research protocol was approved by The National Committee for Research Ethics in Medicine (NEM) in Norway and by The Commission for Science and Technology in Tanzania (COSTECH). Prior to the field study, the local people had been informed about the study through daylong gatherings in the villages, and the village leaders had given consent. The women also consented individually.

#### Results

The overall mean Hb was 12.1 g/dl with a range from 4.5 to 18.1 g/dl. The distribution was approximately normal, with a longer tail towards lower concentrations (Fig. 1). Standardized to sea level according to Dirren et al., mean Hb was 11.4 g/dl (17).

Hb less than 11.0 g/dl was present in 22.7% of the subjects. 4.6% of the participants had Hb <9.0 g/dl and 0.5% had severe anemia defined as Hb <7.0 g/dl. With an Hb standardized to sea level, we found Hb <11.0 g/dl in 36.1%, Hb <9.0 g/dl

in 8.8%, and Hb <7.0 g/dl in 1.1% of the pregnant women.

#### Altitude

Mean altitude for the villages in the study was 1750 meters above sea level with a range of 1300 to 2150 meters. Mean Hb was higher in women living at higher altitudes (Table I). In multiple linear regression analysis there was a highly significant association between Hb and altitude. On average, the Hb increased by 0.29 g/dl per 200 m (Table I) in our range of altitudes (95% CI 0.19–0.38 g/dl). *Additional* adjustment for ethnic or religious affiliation or malaria parasitemia did not alter the effect (not shown in Table). Multiple logistic regression analyses showed that the risk of anemia (hb <9 g/dl) decreased with a factor of 0.6 per 200 meters increased altitude. The proportion of malaria blood slide positives decreased significantly with increasing altitude, the prevalence being 27.2% at altitudes below 1600 m, 19% at 1600–1799 m, 15.5% at 1800–1999 m, and 14.9% at 2000 m and above (*p*-value for trend <0.01).

#### Demographic factors

Mean age of the participants was 26.7 years with a range of 14 to 49. Mean Hb was highest among the youngest women, decreasing slightly with advancing age (Table I). In multiple linear regression analysis, Hb decreased by 0.1 g/dl per 5 years increase of age, and showed the same trend even when parity was adjusted for. Multiple logistic regression analysis of anemia (Hb <9 g/dl) on age showed that the risk of anemia increased with a factor of 1.2 per five years increase of age.

Among those with ethnic affiliation recorded (*n*=2019), Iraqw subjects accounted for 83% of participants, Datoga for 14%, other tribes 2.4%. Mean Hb was lower in the Datoga women as compared to the Iraqw (Table I). Multiple linear regression analysis showed that Datoga women had on average 0.4 g/dl lower Hb than the Iraqw. Multiple logistic regression analyses showed that the risk of odds ratio of anemia was twice as high among Datoga women compared to Iraqw women.

Among those with data on religious affiliation (*n*=1981), Protestants were the largest group (50%) followed by Roman Catholics (26%) and traditional religion (23.4%). Mean Hb was highest for Roman Catholic women and lowest for women with traditional religion (Table I). Multiple linear regression analysis confirmed that the women belonging to the Catholic denomination had 0.3 g/dl higher Hb than the Protestant women. The risk of anemia was also lower in Catholics, although the

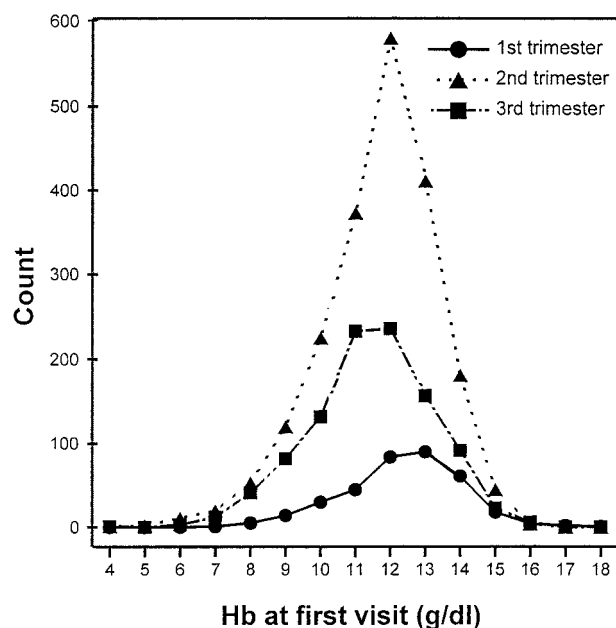


Fig. 1. Hemoglobin distribution among pregnant women attending antenatal clinics in Northern Tanzania, according to stage of pregnancy at first examination.

adjusted OR was not significantly different between the groups.

### Pregnancy related factors

Median gestational age at time of examination was 5 months. Mean Hb was highest in the women attending at the beginning of the pregnancy, decreasing with advancing pregnancy until 8 months of gestation, then rising till the time of delivery (Fig. 2).

Average and median parity was three pregnancies, nulliparae accounting for 20% of the subjects. Mean Hb decreased slightly with increasing parity (Table II), an association similar to that between Hb and age. In univariate regression analysis, this trend was significant, but after adjustment for age, we could not demonstrate any significant relationship with parity (Table II). In multiple logistic regression analysis, there was no association between anemia and parity.

### Season and malaria

Mean Hb was lower in the periods January to June 1995 and January to March 1996 (rainy seasons) than in July through December 1995 (dry season) (Fig. 3 and Table III). Multiple linear regression analysis showed lower Hb during January through June 1995, September through December 1995, and January through March 1996 compared to July through September 1996. Adjusting for malaria parasitemia did not eliminate this effect (not

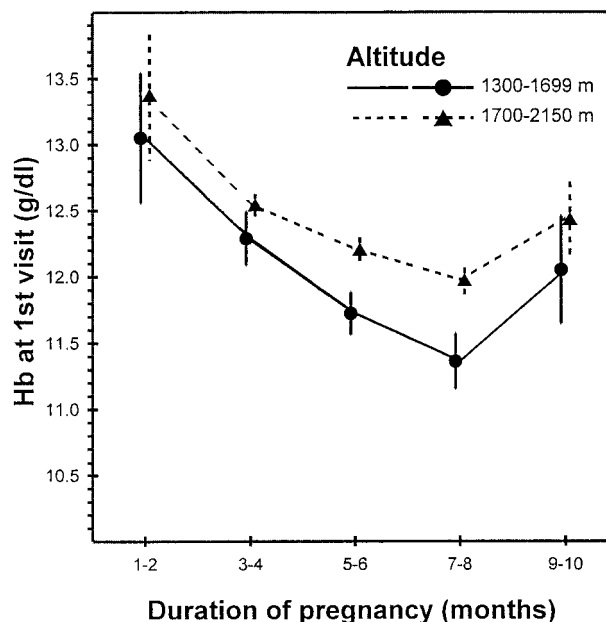


Fig. 2. Mean hemoglobin and 95% confidence interval at different stages of pregnancy among pregnant women attending antenatal clinics in Northern Tanzania.

shown in Table). In multiple logistic regression analysis, the highest risks of anemia (Hb<9.0) were observed in the periods corresponding to the rainy season of 1995 (January through June 1995). The risk of anemia was higher in January till March 1995 than January till March 1996 (OR 3.6, not in Table).

The proportions of women with detectable ma-

Table II. Mean Hb and fraction with anemia in relation to pregnancy related characteristics of pregnant women in Mbulu and Hanang Districts, Tanzania, 1995–1996

Background variable	n <sup>a</sup>	Hemoglobin concentration		Adj. regr. coefficient <sup>b</sup>	Anemia (Hb<9.0 g/dl)	
		mean	(95% CI)		%	Adjusted OR <sup>b</sup>
<b>Duration of pregnancy</b>						
1–2 months	97	13.2	(12.9–13.6)	1.57***	0.0%	0.00
3–4 months	808	12.5	(12.3–12.6)	0.69***	2.8%	0.47**
5–6 months	1476	12.0	(12.0–12.1)	0.31***	4.7%	0.77
7–8 months <sup>c</sup>	769	11.8	(11.7–11.9)	—	5.9%	1.00
9–10 months	249	12.3	(12.1–12.6)	0.57***	4.8%	0.76
<b>Parity</b>						
Para 0	654	12.3	(12.2–12.4)	0.00	4.4%	0.95
Para 1–2	930	12.2	(12.1–12.3)		4.5%	
Para 3–4	762	12.0	(11.9–12.1)		5.4%	
Para 5–6	436	12.0	(11.9–12.1)		3.4%	
Para 7+	420	11.9	(11.8–12.1)		6.9%	

\*  $p<0.05$ ; \*\*  $p<0.01$ ; \*\*\*  $p<0.001$ .

<sup>a</sup> The variables have different numbers of missing values.

<sup>b</sup> Adjusted for woman's age, duration of pregnancy, and altitude. Age and altitude were entered as continuous variables. Adjusted regression coefficient represents the adjusted average difference in Hb (g/dl) between the given groups of the variables in the Table. Odds ratio was used as an approximation for relative risk.

<sup>c</sup> Reference category.



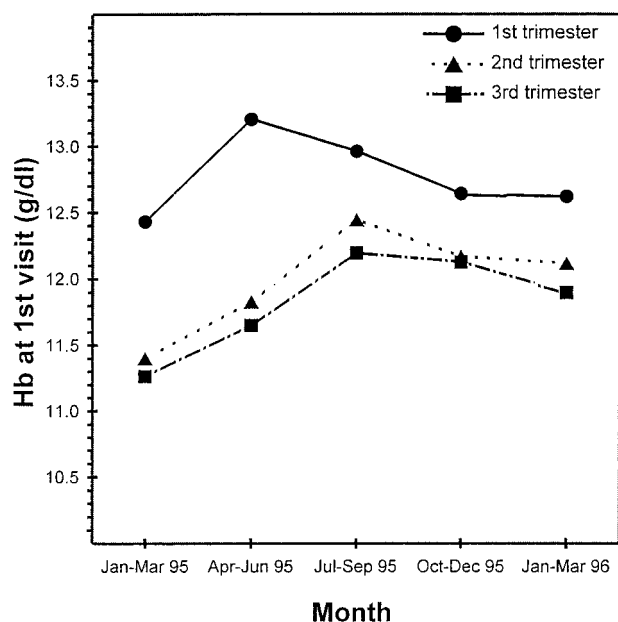


Fig. 3. Mean hemoglobin at different times of examination among pregnant women attending antenatal clinics in Northern Tanzania.

laria parasitemia in the five periods were 33.8% (January through March 1995), 23.3% (April through June 1995), 14.6% (July through September 1995), 11.3% (October through December 1995), and 18.6% (January through March 1996).

The proportion of women with detectable malaria parasitemia was 21.2% in the nulliparous and 17.0% in the parous women. Among the anemic women, 31.5% had malaria parasitemia, compared to only 17.5% among non-anemic women ( $p < 0.001$ ). There was no significant difference in

the proportion of parasitemia between women examined during first, second or last trimester (18.6%, 16.7% and 18.7%, respectively).

In multiple regression analysis, no significant association between Hb and malaria parasitemia was detected (Table III). Multiple logistic regression analysis showed that malaria parasitemia significantly increased the risk of anemia by 80% (OR = 1.8) (Table III). Malaria parasitemia was associated with rainy season ( $p < 0.001$ ) and decreasing altitude ( $p$ -value for trend  $< 0.01$ ).

## Discussion

This cross-sectional study among pregnant women in Tanzania showed that anemia was less common in these rural districts in the northern highlands than reported from most other areas in Tanzania. Our finding of a mean Hb of 12.1 g/dl contrasts other studies showing 10.0, 9.7, and 8.7 g/dl for pregnant women in Dar es Salaam (19), Moshi (18), and Morogoro (21). In many industrialized countries, the mean Hb is around 12 g/dl (12). This study was conducted at a higher altitude than in the studies mentioned above. However, 36% of the pregnant women had anemia. This is a challenge for preventive antenatal care in this area, and knowledge on the specific etiology in this area is needed.

Hb has been shown to depend on altitude, and in order to detect anemia in highlanders, several models for correction have been proposed. WHO and CDC recommend the use of a correction factor that is subtracted from the measured Hb in order to get an adjusted Hb (or added to the anemia cut-off value). The table of correction factors for

Table III. Mean Hb and fraction with anemia in relation to season and malaria parasitemia among pregnant women in Mbulu and Hanang Districts, Tanzania, 1995–1996

Background variable	$n^a$	Hemoglobin concentration			Anemia (Hb < 9.0 g/dl)	
		mean	(95% CI)	Adj. regr. coefficient <sup>b</sup>	%	Adjusted OR <sup>b</sup>
<b>Season</b>						
Jan-Mar 95	408	11.6	(11.4–11.7)	−0.88***	11.5%	6.02***
Apr-Jun 95	747	11.8	(11.7–12.0)	−0.50***	7.0%	3.35***
Jul-Sep 95 <sup>c</sup>	988	12.5	(12.4–12.6)	—	2.2%	1.00
Oct-Dec 95	983	12.2	(12.1–12.3)	−0.24**	3.3%	1.75
Jan-Mar 96	710	12.1	(12.0–12.2)	−0.34***	3.5%	1.85
<b>Parasitemia</b>						
Neg. <sup>c</sup>	2982	12.2	(12.1–12.2)	—	3.8%	1.00
Pos.	660	12.0	(11.9–12.2)	−0.16	7.9%	1.79**

\*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ .

<sup>a</sup> The variables have different numbers of missing values.

<sup>b</sup> Adjusted for woman's age, duration of pregnancy, and altitude. Age and altitude were entered as continuous variables. Adjusted regression coefficient represents the adjusted average difference in Hb (g/dl) between the given groups of the variables in the Table. Odds ratio was used as an approximation for relative risk.

<sup>c</sup> Reference category.

Hb at specific altitudes is based on a study from South America by Hurtado et al. (26), and describes an exponential (square) rise in Hb, increasing from sea level to 1000 m by 0.2 g/dl, at 2000 m by 0.7 g/dl, and at 3000 m by 1.6 g/dl (13). A simplified correction factor of 4% per 1000 m has been used (27), but it gives misleading correction at extreme altitudes. Based on data from 469 Equadorian children, a more complicated correction formula was developed by Dirren et al. (17), producing corrections not very different from Hurtado et al. Using this formula at our altitude range, the correction factor from 1300 m (0.44 g/dl) to 2150 m (1.0 g/dl) increased on average by 0.13 g/l per 200 m altitude. In our study, the average increase in Hb from 1300 m to 2150 m was 0.29 g/dl with a 95% CI from 0.19–0.38 g/dl. The steeper increase in Hb with altitude in our population may indicate that the correction factors provided by Dirren and WHO are inadequate in this area. Another possible explanation for the difference in hemoglobin-altitude relationship, is confounding with nutritional status and with malaria associated anemia. In our study, the lower situated areas were drier and less fertile (28), which may have affected the nutritional status of the population. In addition, malaria was more common at low altitudes. Both of these factors may potentially have caused more anemia in the women living at lower altitude compared to those at higher altitude, and led to an overestimation of the effect of altitude on Hb. However, adjustment for malaria parasitemia did not alter the relationship. The study done by Dirren et al. in South America did not describe the general nutritional status or soil conditions, but iron deficient subjects were excluded.

This study was conducted at antenatal clinics covering around 57% of the estimated number of pregnant women in the area. Most of the remaining 43% may have attended a clinic that was not included in the study, and some may not have attended antenatal clinics at all. The coverage of antenatal care is generally very high (90–98%) in Tanzania (29). Thus, although the sample was not randomly selected, there is no obvious reason to believe that the sample should not be representative for the pregnant women in the area.

This study suggests a small decrease in Hb with increasing age and parity, and is in accordance with many other studies. Whether the effect on Hb is the maternal age in itself or repeated childbearing, is a controversial matter. The Hb decreased significantly with advancing age even when adjusting for parity, but we did not find any decrease in Hb with increasing parity when adjusting for age. In contrast, Jackson et al. (Zaire, 1991) did not find any effect of age after adjusting for parity,

but showed increasing Hb with increasing parity (30). Our findings may imply that in our study area childbearing *per se* does not have long term detrimental effects on the woman's hematological status, but her age does. However, one must bear in mind that the effect of age is very small, Hb decreasing only 0.1 g/l per 5 years of age.

The women of Datoga ethnic affiliation had a lower Hb than the Iraqw. This finding was not surprising and may be due to a better nutritional status of the Iraqw. The Iraqw are typically agro-pastoralists, whereas many Datoga are pastoralists with less farming experience and less variation in food. We also noticed that the Datoga women had less education than the Iraqw. In an unpublished household survey we conducted in 1995–96 in selected villages in the study area, we found an illiteracy rate of 82% among Datoga women and 52% among Iraqw. In addition, the Iraqw have a tradition of seeking health services, whereas the Datoga are more skeptical (31).

The relationship between Hb and gestational age showed a U-shaped curve (Fig. 2) found in other studies (30, 32, 33). This is generally attributed to the physiological hemodilution and is regarded as normal. The risk of anemia will appear to be higher when dilution is at its maximum (at seven to eight months). These normal physiological changes of Hb demonstrated during pregnancy have led to recommendations for the use of trimester specific cut-off values for anemia (10, 11, 13). Our results indicate that this should be considered also in a population from rural Tanzania. It is not likely that the effect was due to malaria, as malaria parasitemia was not significantly different in first, second and third trimester.

Hb showed a seasonal variation, with lower Hb during the rainy season. A similar relationship was observed in Mali (34). The rather low Hb and high risk of anemia observed in the period January–March 1995 in comparison with January–March 1996 may be due to the severe epidemic of malaria in the rainy season 1995, which was also reflected in the proportion of malaria parasitemic women in that period. However, adjusting for malaria parasitemia did not eliminate the differences between 1995 and 1996. Annual variations have been observed in other studies in Tanzania (18).

Malaria parasitemia was associated with anemia (OR=1.8). This has been shown in studies from several areas including Dar es Salaam (35), Zanzibar (20), and Zambia (36). Our findings suggest that there is a potential for reducing anemia by controlling malaria even at altitudes close to 2000 m. The national policy for antenatal care includes free prophylactic chloroquine tablets during pregnancy, but implementation is poor due to lack of

resources. Malaria could explain some of the seasonal variation in Hb in our study, but some of the effect of season on anemia remained even after adjustment for parasitemia. The implication may be that the seasonal variation of Hb also depends on other factors, like nutrition and time of harvesting. Also, malaria parasitemia, as measured by blood slide, may not be a sensitive indicator of malaria disease (37), and malarial anemia can occur without detectable parasitemia.

Other diseases commonly associated with anemia, like leishmaniasis and shistosomiasis, intestinal worms and sickle cell disease, were uncommon in this area (38). In a sub-sample of the study subjects, only one out of 146 stool specimens showed hookworm ova. HIV prevalence among pregnant women attending the antenatal clinics of Haydom Lutheran Hospital was 0.3% (HLH 1996, unpublished). These factors may also contribute to a lower prevalence of anemia compared to other parts of Tanzania.

## Conclusion

This study on anemia among rural pregnant women in Tanzania living at altitudes of 1300 to 2150 m, showed that 36% had a sea-level standardized Hb of less than 11.0 g/dl and confirms that anemia is a major challenge in preventive antenatal care even in this area. However, the prevalence was lower than observed among pregnant women in most other parts of Tanzania, which could partly be explained by the altitude and rarity of some diseases commonly causing anemia. Further studies on the micro-nutrient status of the women are needed to identify more specific etiological factors.

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