Nigerian Journal of Paediatrics 1982; **9** (**2**): 45–50

A Study of Anaemia and Malaria Infection among Rural and Urban Children

FM Akinkugbe*

Summary

Akinkugbe FM. A Study of Anaemia and Malaria Infection among Rural and Urban Children. *Nigerian Journal of Paediatrics* **1982; 9: 45.** The association between malarial infection and anaemia was studied in three hundred rural and urban children, aged between one and seven years. The incidence of malaria parasitaemia was higher in urban than in rural children. Hepatosplenomegaly occurred more frequently in children, aged 4 to 6 years, who had malaria parasitaemia associated with anaemia than in those without anaemia. There was no significant relationship between the prevalence of malaria parasitaemia and the haemoglobin genotype although there was some evidence that the sickling gene protects against anaemia in children with malaria and haemoglobin genotype AS.

Introduction

Anaemia and malaria are two important causes of childhood morbidity and mortality in developing countries. Reports so far, indicate that there is a definite causal relationship between these two clinical conditions.[1 2] Anaemia in malaria infection is caused mainly by parasitisation and eventual destruction of the red cells by the plasmodium[3 4] but destruction of unparasitized red cells also occurs to some extent. Toxic inhibition of the bone marrow leads to anaemia,[5 6] often with evidence of normoblastic hyperplasia and myelocytic proliferation. There is also stasis of blood in the extrasinusoidal tissue, occurring as a result of changes on the surface of the red cells and leading to an increase in plasma volume which in turn, results in a dilutional factor superimposed on the haemolytic anaemia. Chronic malaria leads to megaloblastic anaemia, as folic acid deficiency follows rapid and continuous destruction of red cells in an individual whose folic acid intake is precariously marginal.[7]

The purpose of the present investigation was to explore further, the association between anaemia and malaria, and also to examine factors that might be interrelated in the pathogenesis of these two conditions in urban and rural children.

Materials and Methods

Children, aged between one and seven years, attending for the first time, the General-Out-Patient Department (GOPD), University College Hospital (UCH), Ibadan, and Oluyoro Catholic

University of Ibadan, Ibadan

Institute of Child Health

*Senior Research Fellow

Mission Hospital (OCMH), Ibadan, were examined. These children constituted the urban group. Similarly, all rural children aged between 1 and 7 years, attending for the first time, the Rural Health Centre at Igbo-Ora (a village, 80 kilometres north-west of Ibadan) were examined until the number required had been seen. In order to exclude children who might have had antimalarials for "fever" during the previous three weeks and those who were on long-term antimalarial prophylaxis, it was decided to examine only those who had not received any form of antimalarial therapy during the month preceding their first attendance. Admittedly, it was not always easy to attest the reliability of mother's history in this regard.

Each child was examined for the presence of enlarged spleen and liver and the findings were recorded in centimetres below the appropriate costal margin. Capillary blood was collected from each child by a finger prick, using Hacksley's disposable lancet and the following investigations were carried out from the blood samples: malaria parasite counts, haemoglobin (Hb) and packed cell volume (PCV) estimations, haemoglobin typing and leucocyte counts. Haemoglobin estimation was by the cyamethaemoglobin method using Drabkin's reagent as the diluent.

The total number of children thus seen at GOPD, OCMH and Igbo-Ora were 146, 260 and 120 respectively. For the final selection into the study, the first 25 consecutive children, aged between 1 and 4 years, and the first 25, aged between 4 and 7 years, all with haematocrit values 30% and below were picked from the GOPD, OCMH and Igbo-Ora health centre groups. These represented the anaemic group. A similar selection was undertaken in respect of children with haematocrit of over 30 per cent to represent the non-anaemic group. Statistical analysis of the data obtained was done by using the chi-squared tests.

Results

The total number of children finally selected was 300, (150, aged 1 to 3 years and 150, aged 4 to 6 years).

The incidence of malaria parasitaemia in the various groups is shown in Table I. This was significantly higher in the 1 to 3-year-old children from OCMH than in the 1 to 3-year olds from Igbo-Ora and GOPD ($p < 0.05$). Similarly, in the 4 to 6-year age group, the incidence of malaria parasitaemia was higher in the OCMH group compared with the 4 to 6-year olds from Igbo-Ora and GOPD groups, although the difference in this instance was not statistically significant.

The malaria parasite density appeared similar in all the three institutions (Igbo-Ora, OCMH and GOPD) and the values varied between $64.10^9/l$ and $1250.10^9/l$. The level of haematocrit did not correlate with the malaria parasite density in most instances but few subjects with very high parasite density had rather low haematocrit levels, especially among children aged, 1 to 3 years. The malaria parasitaemia rate in all the groups combined, was significantly higher in the anaemic children than in the non-anaemic children ($p < 0.01$ in 1 to 3-year olds; $p < 0.01$ in 4 to 6-year olds) (Table I).

Table II shows the association between malaria parasitaemia, hepatosplenomegaly and anaemia in the three institutions. Most of the children with anaemia and malaria also had hepatosplenomegaly. The incidence of hepatosplenomegaly was significantly higher in the children with malaria parasitaemia in the two age groups compared with the children without malaria parasitaemia ($p < 0.001$). Hepatosplenomegaly rate was also significantly higher in children with malaria and anaemia compared with children with malaria without anaemia ($p < 0.05$ and $p < 0.05$ in 1 to 3-year and 4 to 6-year groups, respectively).

TABLE I

Malaria Parasitaemia Rate in 300 Rural and Urban Children

Institution	*Age (Years)*					
	1–3			4–6		
	Anaemic	*Non-Anaemic*	*Total*	*Anaemic*	*Non-Anaemic*	*Total*
	% of 25	% of 25	% of 50	% of 25	% of 25	% of 50
Oluyoro Hospital	76	28	52	76	24	50
General Out-Patient Dept. UCH	40	20	30	52	24	38
Igbo-Ora Health Centre	48	16	32	52	20	36
Total	53.7	21.3	38	60	22.7	41.3

TABLE II

Association between Malaria Parasitaemia, Hepatosplenomegaly and Anaemia in 300 Rural and Urban Children

Institution	*Age (Years)*			
	1–3		4–6	
	Anaemic	*Non-Anaemic*	*Anaemic*	*Non-Anaemic*
Oluyoro Hospital (Urban)	13 (14)	2 (6)	12 (15)	3 (7)
General Out-Patient Department (Urban)	7(10)	3 (8)	7 (11)	4 (12)
Igbo-Ora Health Centre (Rural)	7 (12)	2 (2)	9 (15)	4 (11)
Total	27 (36)	7 (16)	28 (41)	11 (30)

Figures in parentheses indicate children with hepatosplenomegaly and those without parentheses indicate children with malaria and hepatosplenomegaly.

Table III shows the relationship between malaria parasitaemia and the Hb genotypes in the different groups. There was a high incidence of malaria with anaemia in children with Hb genotype A while there was no case of malaria parasitaemia in children with Hb genotype SS or SC. The percentage occurrence of malaria parasitaemia was highest in children with Hb genotype AC but the numbers were small. On the whole, there was no significant difference in the incidence of malaria between Hb genotype A and AS, in the non-anaemic group. However, in the anaemic group, a significantly lower percentage of children with Hb genotype AS had malaria parasitaemia as compared with those with Hb genotype A ($p < 0.05$).

Table IV shows the incidence of severe malaria parasitaemia (malaria parasite count of $10.10^9/l$ or above) in the different haemoglobin types. There was no significant difference in the

prevalence of anaemia with severe malaria in the different haemoglobin genotypes. There was also no significant difference between the mean leucocyte count in children with malaria infection and the overall mean leucocyte count (Table V).

Most of the children in the three groups had *P. falciparum* infection. There were five children from the rural population who had mixed infection with *P. falciparum* and *P. malariae* and three with *P. malariae* infection only. The malaria parasite among the GOPD group was exclusively *P. falciparum*. There was no child with *P. ovale* infection, although this has been reported in about one per cent of all cases of malaria seen in the Western State of Nigeria.[8]

TABLE III

Incidence of Malaria Parasitaemia and Anaemia in 295 Children with different Haemoglobin Genotypes

	Haemoglobin Genotypes					
	AA	*AS*	*AC*	*SS*	*SC*	*CC*
Total No. of Children	196	70	19	7	2	1
Total No. of Children with Anaemia	98	32	9	6	1	–
Total No. of Children with Malaria	84	27	8	–	–	–
Total No. of Children with Malaria and Anaemia	64	14	8	–	–	–
Prevalence of Malaria Parasitaemia (%)	42.9	38.6	42.1	–	–	–
Prevalence of Malaria in anaemic children (%)	65.3	43.8	88.9	–	–	–

TABLE IV

Prevalence of "Severe" Malaria Infection In 295 Children with Different Haemoglobin Genotypes*

	Haemoglobin Genotypes					
	AA	*AS*	*AC*	*SS*	*SC*	*CC*
Total No. of children	196	70	19	7	2	1
Total No. of children with severe malaria	23	8	2	–	–	–
Percentage prevalence of severe malaria	11.7	11.4	10.5	–	–	–
Total No. of children with anaemia	98	32	9	6	1	–
Total No. of children with severe malaria and anaemia	18	6	2	–	–	–
Percentage prevalence of severe malaria in anaemic children	18.4	18.8	22.2	–	–	–

* Malaria Parasite Density of 10.10^9/l or above.

TABLE V

Mean Leucocyte Count in 292 Rural and Urban Children

	Mean (per mm)^3	*SE*	*n*
Anaemic & non-anaemic 1–3 years	10.050	0.481	149
Anaemic & non-anaemic 4–6 years	7.841	0.298	143
Anaemic & non-anaemic 1–3 & 4–6 years	8.968	0.285	292
Malaria parasitaemia 1–3 years	9.649	0.962	57
Malaria parasitaemia 4–6 years	7.257	0.401	63
Malaria parasitaemia 1–3 & 4–6 years	8.393	0.493	120

SE = Standard error
n = Number of children

Discussion

Malaria infection is a well-recognised cause of childhood anaemia in the tropics, especially in areas with stable malaria.[1 2 6 9] The present study has thus confirmed this previous observation. A high percentage of the anaemic children in all the three groups had malaria parasitaemia: 54% in the 1–3-year olds and 60% in the 4–6-year olds. The malaria parasitaemia rate was much lower in the urban GOPD children than in the OCMH group. This may be partly due to the fact that the UCH, a teaching and referral hospital, is not normally the first port of call for patients. It is only those children considered by the parents to be severely ill who are brought to the UCH. These ill children were thus a selected group in contrast to those who attended the OCMH, which is a general hospital. The malaria parasitaemia rate among the OCMH group of children was much higher than that among rural children from Igbo-Ora. This observation is at variance with a previous report that malaria parasitaemia was higher in rural than in urban children.[10] This may, however, be attributed to the fact that the OCMH group of children included those from both rural and urban parts of the city. The presence of a good health centre in Igbo-Ora (which has a close link with the University of Ibadan Medical School) might also have influenced the general state of health of children in this area.

The degree of anaemia in the present study did not correspond to the level of parasitization of the red cells in all instances. This may be due to the development of auto-antigen which leads to the production of auto-antibody in some individuals as has been found to occur in mice.[11]

Hepatic and splenic enlargement occur frequently in children with malaria.[12–15] The incidence of hepatosplenomegaly in the present study was slightly higher (79%) among children aged 1 to 3 years than (73%) among those aged 4 to 6 years. There was also a significant association between hepatosplenomegaly and malaria parasitaemia in both age groups. In children with malaria, aged 4 to 6 years, a significantly higher prevalence of hepatosplenomegaly occurred among the anaemic than among the non-anaemic group.

The prevalence of malaria parasitaemia in the children with Hb genotype A was only slightly higher (42%) than (39%) in those with Hb genotype AS. Similarly, the prevalence of severe malaria parasitaemia in Hb genotype A was similar to that in Hb genotype AS (11.8% and

11.4% respectively). It is however, well established that malaria infection occurs more frequently in children with Hb genotype A than in those with Hb genotype AS.[16] This may be because red cells with sickling genes are rapidly destroyed once they are parasitised, due to the low oxygen tension created by the parasite, and are promptly removed from the circulation.[17] This situation would then lead to severe anaemia if red cell destruction is great, such as in sickle-cell crisis. In the case of children with Hb genotype AS however, the toxicity or severity of malaria infection is much less conspicuous. The present study has partly supported the above hypothesis, although there is hardly any difference in the prevalence of malaria infection in children with Hb A compared with Hb genotype AS. Nevertheless, it has been shown in the present study that children with Hb genotype AS may not develop anaemia readily with malaria infection. It is significant that out of nine children examined, there was none with malaria parasitaemia in the group with Hb genotype S. It seems probable that the parasitized cells in this group would have been quickly destroyed, thus causing moderate or severe anaemia.

References

1. Hendrickse RG and King MAR. Anaemia of uncertain origin in infancy. *Br Med J* 1952; **2:** 66–9.
2. McGregor IA, Williams K, Billiewicz WC and Thomson AM. Haemoglobin concentration and anaemia in young West African (Gambian) children. *Trans Roy Soc Med Hyg* 1966; **60:** 650–67.
3. Srichaikul T, Panikbutr N and Jeumtrakul P. Bone marrow changes in human malaria. *Ann Trop Med Parasit* 1967; **61:** 40–51.
4. Devakul K, Harinasuta T and Kankakorn K. Erythrocyte destruction in Plasmodium falciparum malaria: an investigation of intravascular haemolysis. *Ann Trop Med Parasit* 1963; **63:** 317–25.
5. Bell S. The effects of changes in nutrition on the host-parasite relationship-anaemia and parasitism in man. *Proc Nutr Soc* 1962; **22:** 1–8.
6. Edington GM and Gilles HM. In: Pathology in the Tropics. London: Edward Arnold Ltd, 1969: 22.
7. Jolly H. In: Diseases of Children. Oxford: Blackwells Scientific Publication. 1968: 307.
8. WHO. *Tech Rep Ser* 1969; **No. 433.**
9. Topley E. Common Anaemia in rural Gambia II-Iron deficiency anaemia among women. *Trans Roy Soc Trop Med Hyg* 1968; **62:** 602–6.
10. Gilles EM. In: Akufo, An environmental study of a Nigerian village community. Ibadan: Ibadan University Press, 1964: 65.
11. Zuckerman A. Immunity in malaria with particular reference to red cell destruction. In: Immunity in Protozoa. Garnham PCC, Pierce AE and Rott IM, eds. Oxford: Blackwell Scientific Publications, 1963: 73–87.
12. Maegraith BG. In: Pathological Processes in Malaria and Blackwater Fever. Oxford: Blackwell Scientific Publications, 1948: 290.
13. Colbourne MJ, Edington GM and Hughes MH. A medical survey on a Gold Coast Village. *Trans Roy Soc Trop Med Hyg* 1950; **44:** 271–90.
14. McGregor IA and Smith DA. A health nutrition and parasitological survey in a rural village (Keneba) in West Kiang, Gambia. *Trans Roy Soc Trop Med Hyg* 1952; **46:** 403–27.
15. McGregor IA, Gilles HN, Walters JH and Davies AH. Effects of heavy and repeated malarial infections on Gambian infants and children. *Br Med J* 1956; **2:** 686–92.
16. Allison AC. Protection afforded by sickle-cell trait against subterian malarial infection. *Br Med J* 1954; **1:** 290–4.
17. Luzzatto L, Nwachuku-Jarret ES and Reddy S. Increased sickling of parasitised erythrocytes as mechanism of resistance against malaria in the sickle cell trait. *Lancet*, 1970; **1:** 319–22.

Accepted 29 December 1981