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Malaria in urban and rural areas of southern Ghana: a survey of parasitaemia, antibodies, and antimalarial practices

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A comparative cross-sectional survey was undertaken in two populations, urban and rural, in southern Ghana to assess the impact of urbanization on the prevalence of malaria parasitaemia and antibodies. At the same time, a survey of antimalarial practices was conducted on sample populations in the two communities. The results showed a low parasite rate (1.6%) and correspondingly low titres of malaria antibodies in a significant proportion of the urban community, particularly in children less than 10 years old. This was associated with widespread use in the urban community of antimalarial drugs, particularly chloroquine, as prophylaxis. The parasite rate in the rural community was 22%, and 97% of the sample population over 1 year of age had antibodies against Plasmodium falciparum. *These results demonstrate that a substantial proportion of urban children are growing up with little exposure to malaria, even in a region considered endemic for malaria. The implications of these findings are discussed.*

Malaria is the greatest cause of morbidity and a large contributor to mortality in tropical Africa. A World Health Organization Scientific Group has estimated that this disease kills more than one million people each year, mainly children (*1*). Much of the information about the prevalence of malaria in tropical Africa was collected in the late 1950s and 1960s during feasibility studies, which indicated that malaria could not be eradicated with the available technology (*2*). Since then, major social changes have occurred throughout Africa, with, in particular, a marked trend towards urbanization. In Ghana, West Africa, these social changes, particularly among the urban population, are reflected in increasing numbers of educated and relatively affluent persons, more widespread knowledge about health and disease, and greater access to health care facilities.

In order to ascertain the impact of urbanization on malaria distribution, we undertook a comparative cross-sectional survey of two populations in southern Ghana: one in Ablekuma, an urban district of Accra, and the second in Berekuso, a village in the Eastern Region. The survey principally investigated parasite prevalence, antimalarial antibodies and antimalarial practices in the two communities.

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BACKGROUND

Ablekuma district, Accra

The city of Accra is a rapidly growing metropolis of more than one million people located along the Gulf of Guinea in a semi-arid coastal plain. Ablekuma district (also known as Mamprobi) is a residential area on the western side of central Accra. Approximately 10% of the population of Accra live in this district in 7049 households, according to a Sanitary Department survey carried out in 1978. The population is mixed in terms of education and affluence, but is generally middle level for Accra. Housing varies considerably in quality. Of the houses in our survey, 12% were rudimentary, with mud walls (often plastered with concrete) and sheet metal roofs, and no services or indoor toilet. About 8% of houses had concrete-block walls, toilet, running water, electricity, and windows with screening or glass.

The medical needs of this population are provided by the Mamprobi Polyclinic as the primary care centre, as well as by private medical sources. Korle Bu Teaching Hospital and Medical School are also

located in this area but serve primarily as a referral centre. Polyclinic services include an active outreach effort involving public health nurses and aides. No systematic antimosquito spraying programme has been undertaken in Ablekuma in recent years although high-density breeding sites are sprayed occasionally.

Berekuso, Eastern Region

The village of Berekuso is located in the foothills of the Aburi Ridge, north of Accra, in a rural area. At the time of the study, it had approximately 1000 inhabitants living in 120 houses and appeared to have grown little, if at all, in recent years. Housing is uniformly of the type described above as rudimentary. Most adults are engaged in farming. Although only 56 km from Accra, the village is 11 km from a paved road and 19 km from the nearest medical facility. However, it is served on a weekly basis by a mobile health unit from the Danfa Health Project (*3*). In this respect Berekuso should be regarded as a rural village with some access to health services. According to local inhabitants, no antimosquito programme has ever been attempted in Berekuso.

Both surveys were conducted in October and November 1978, just after the minor rainy season. (In southern Ghana rains generally occur in May–June (major) and September–October (minor).)

METHODS

In January 1978, employees of the Sanitary Department of Accra tabulated the address of every house in Ablekuma district. From this list of 7049 houses, a 2% sample was selected at random. Each house was visited by a team of 2 or 3 people. All residents of the household (those sleeping there) were listed and a sample of up to 5 persons was selected comprising: the adult nearest to 40 years old (excluding pregnant women), children nearest to 10, 5, and 3 years of age, and the oldest infant aged less than 1 year. If the indexed house could not be located at the address listed, or if it was unoccupied, the house nearest the putative address was selected. Also, if the household contained no children, or the occupants refused to take part in the survey for any reason, the nearest house was taken as a substitute.

Of 141 houses in Ablekuma district selected by random draw, 124 were included in the final survey. Of these, 92 (74.2%) were the households indicated in the original sample, and 32 (25.8%) were substitutes. Incomplete interview information or missing laboratory data resulted in elimination of 8 households. The final sample size was 413 persons. In the event that a selected person was unavailable or refused to participate, the nearest age-appropriate alternative was substituted. Adult males were underrepresented, since many were not at home during the day.

The survey in Berekuso was done concurrently. All houses were first mapped and numbered. Odd-numbered houses were visited and the residents tabulated and selected for survey and interview. Some of the 120 houses in the village appeared abandoned and were therefore excluded. The final survey included 36 houses, 7 (19%) of which were substitutes for unoccupied houses or households refusing to participate. The surveyed households had 302 residents, from which 137 were selected for sampling. As in Ablekuma district, adult males were underrepresented as many were absent during the time of the survey.

After obtaining consent, blood samples were taken from all selected subjects by fingerprick, and thick and thin smears and 6 microhaematocrit tubes of blood were prepared. Plasma obtained from the latter was diluted 1:10 in normal saline and stored at -70 °C until it was tested for antibody. Antimalarial antibody titres were determined according to standard immunofluorescent techniques using *P. falciparum*, *P. ovale*, and *P. malariae* antigens (*4*). Reciprocal titres > 10 were considered to be positive. Slides were reviewed by two experienced technicians from the Department of Child Health of the University of Ghana Medical School; malaria species were identified by Dr William Chin of the Centers for Disease Control, Atlanta, GA, USA.

In both Ablekuma and Berekuso, selected individuals (or in the case of children, a parent) were then interviewed about recent febrile illness, the use of "antimalarial" drugs and antimosquito practices. Febrile illness was defined as any episode characterized by feverishness, with or without rigors, headache or general body aches and pains. An "antimalarial" drug was defined as any medication taken by the individual for the treatment of a febrile illness. The exact nature of the drug was determined by further questioning or by actual identification of the drug by the interviewer. The drugs normally proved to be either analgesic/antipyretics or chloroquine. Antimalarial practices were ascertained by direct questioning on the use of antimosquito coils, sprays, and bed-nets. The interview followed a set questionnaire designed for the study.

RESULTS

Ablekuma

Only 6 (1.4%) of 417 urban residents were found to have circulating malaria parasites, all of which were

Table 1. Prevalence of parasitaemia in southern Ghana by age group

Age group	Ablekuma district			Berekuso village		
	No. examined	No. positive	% positive	No. examined	No. positive	% positive
0–5 months	23	0	0	6	0	0
6–12 months	23	1	4	5	2	40
1–2 years	85	2	2	15	2	13
3–4 years	68	2	3	22	6	27
5–6 years	40	0	0	15	5	33
7–8 years	40	0	0	17	4	23
9–10 years	22	0	0	15	4	27
⩾ 11 years	112	1	1	42	8	19
Total	413	6	1.5	137	31	23

identified as *P. falciparum*. No one was heavily infected, but the degree of parasitaemia was not more specifically quantified. The age distribution of subjects is presented in Table 1. Of the 6 positive blood films, 5 were from children under 4 years old.

Antibody titres against malaria fell to a minimum at 6 months of age and rose thereafter. Every infant under 6 months old had some antibodies to malaria antigens, probably representing passively transferred maternal antibodies. The percentage of subjects with a positive titre against *P. falciparum* antigens rose rapidly with age, more than 50% of children 1–2 years old having positive titres. The proportion of subjects with antibodies against *P. ovale* and *P. malariae* rose more slowly with age, reaching 50% in the 7–8-year age group for *P. ovale*, and only in adulthood for *P. malariae* (Fig. 1). Titres against *P. falciparum* antigens were higher than those against *P. ovale* or *P. malariae* antigens in 226 (77.9%) of the 290 subjects over 6 months old who had at least one positive titre. In another 37 subjects (12.8%), anti-*P. falciparum* titres were as high as those against *P. ovale* or *P. malariae*. Of the remaining 27 (9.3%) subjects, the anti-*P. ovale* titre was highest in 18 persons and the anti-*P. malariae* titre in 9 persons.

There was considerable individual variation in antimalarial antibody titre at all ages. Titres against *P. falciparum* (in seropositive subjects only) rose slowly throughout childhood and were highest among adults. Antibody titres against *P. ovale* and *P. malariae* rose more slowly than those against *P. falciparum*, with fewer very high titres in either children or adults (Fig. 2). Titres specifically against *P. falciparum* (the predominant parasite species in Ghana) ranged from < 1:10 to 1:640 in children under 10 years and from < 1:10 to 1:5120 in adults. In Ablekuma, 40% of children aged 1–10 years and 7% of adults had no detectable antibodies (titre < 1:10)

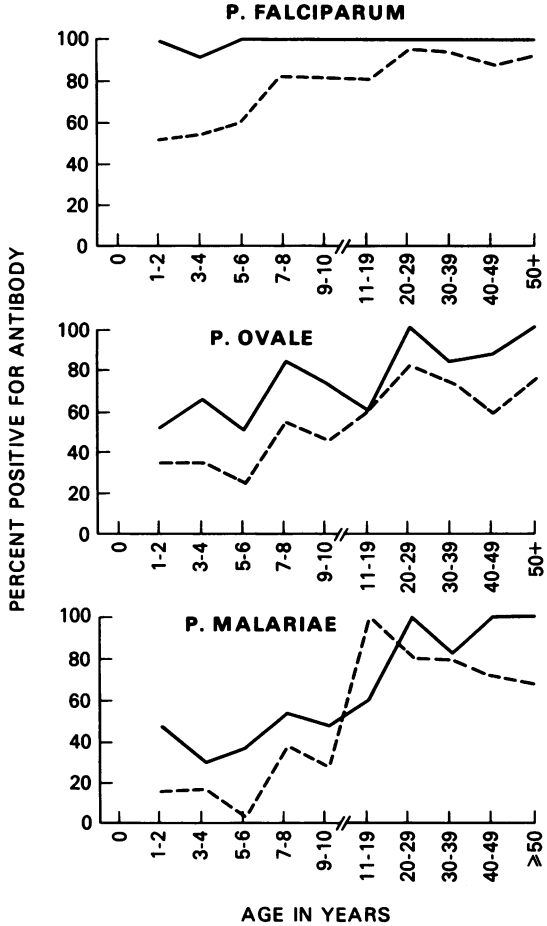

Fig. 1. Percentage of subjects positive for antibodies to malarial antigens by age:
—— Berekuso; --- Ablekuma.

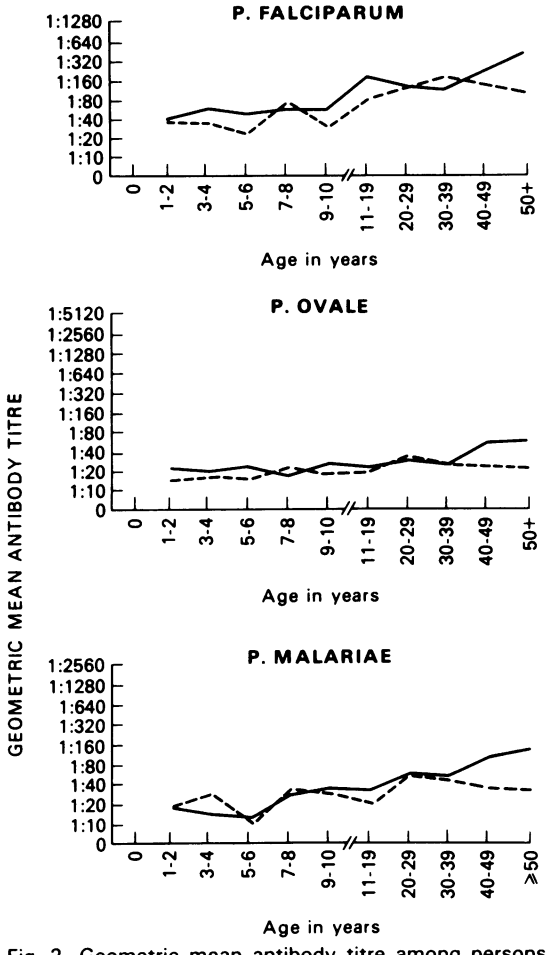

Fig. 2. Geometric mean antibody titre among persons positive for antimalarial antibodies by age:
—— Berekuso; --- Ablekuma.

against *P. falciparum* (Table 2). There was no sex-related difference in either presence of any antibody or titre levels among those who were seropositive.

Berekuso

Of the 138 residents in Berekuso, 31 (22%) had circulating parasites. Parasitaemia was very low in 20, low in 8, and moderate in 3; there was no heavy infection. There was one case of infection with *P. ovale*; all other identified parasites were *P. falciparum*. There was no age-related pattern in the prevalence of parasitaemia (Table 1).

Positive antibody titres (> 1:10) against *P. falciparum* were found in all but 4 (3.4%) persons (aged 3, 3, 12, and 13 years) over 1 year of age (Table 3). Antibody titres against *P. ovale* and *P. malariae* rose more slowly with age but were positive in 93% and 88% of adults respectively (Fig. 1). There was no sex-related difference in presence of antibody or titre levels. Among those with positive titres, antibody levels rose steadily throughout childhood and adult life. Of 126 persons over 6 months old with at least one species-specific positive titre, the anti-*P. falciparum* titre was highest in 106 (84%), and equal to that for *P. ovale* or *P. malariae* in 13 (10%). In 4 persons the anti-*P. malariae* titre was highest and in 3, the anti-*P. ovale* titre (Fig. 2).

Antimalarial and antimosquito practices

Details of the interview data are given in Table 4. Fever was experienced commonly by the sampled populations in both Ablekuma and Berekuso, with 39% and 43% of respondents, respectively, having had a febrile episode within the previous 2 months, and 17% and 19%, respectively, within the previous week. There was no significant difference in the frequency of febrile attacks experienced by individuals in the two populations.

Table 2. Distribution of falciparum antibody titres in Ablekuma by age group

	Reciprocal titre									
Age group	< 10	10	20	40	80	160	320	640	1280	Total
0-5 months	6	2	5	5	3	2	0	0	0	23
6-12 months	13	3	2	2	0	0	1	1	1	23
1-2 years	42	8	13	6	7	6	2	1	0	85
3-4 years	32	9	10	7	3	4	2	1	0	68
5-6 years	16	7	9	3	2	2	1	0	0	40
7-8 years	7	3	5	9	3	6	4	3	0	40
9-10 years	4	8	3	2	1	3	0	1	0	22
⩾ 11 years	7	5	7	1	17	27	24	13	1	112
Total	127	45	54	45	36	50	34	20	2	413

Table 3. Distribution of falciparum antibody titres in Berekuso by age group

Age group	Reciprocal titre									Total
	< 10	10	20	40	80	160	320	640	1280	
0–5 months	4	0	0	0	1	1	0	0	0	6
6–12 months	3	0	0	2	0	0	0	0	0	5
1–2 years	0	0	0	5	4	4	1	1	0	15
3–4 years	0	2	2	7	5	3	2	1	0	22
5–6 years	0	0	0	4	7	2	1	1	0	15
7–8 years	0	0	0	7	3	2	4	1	0	17
9–10 years	0	0	0	5	2	2	4	1	1	15
⩾ 11 years	0	2	3	6	11	14	4	1	1	42
Total	7	4	5	36	33	28	16	6	2	137

Most people in both communities (87% in Ablekuma and 94% in Berekuso) treated their febrile episodes themselves; the drug most commonly used was chloroquine. Interestingly, urban dwellers were more likely than the rural inhabitants to use an antipyretic/analgesic drug. This was probably because they had access to over-the-counter drugs while the rural population depended on the mobile health clinic for their supplies. Only chloroquine was supplied to them.

Regular use of antimalarial drugs for prophylaxis was fairly common in Ablekuma district (37%). Chloroquine was the most popular drug and was taken regularly and in appropriate doses by the people who used it. On the other hand, only 4 respondents (3%) in Berekuso were taking prophylactic antimalarials.

The members of the rural community did not apply personal antimosquito measures. None of the houses had mosquito proofing and no one used bed-nets, mosquito coils, or sprays. In the urban community very few of the houses were proofed against mosquitos, but 49% of respondents used either mosquito coils or sprays daily, another 32% used them occasionally, and 9% used mosquito bed-nets at night.

DISCUSSION

Few population surveys of malaria prevalence have been carried out in Ghana since the mid-1960s, when a rural area of the Volta Region was found by a WHO malaria surveillance unit to have a parasite rate of 55% (Ministry of Health of Ghana, unpublished data, 1965). No age breakdown was available. During the same period (1964–65), in a survey of parasitaemia among children under 5 years old, Ringelhann et al. (*5*) found infection rates varying between 11.8% for central Accra and 22% for more peripheral areas of the city. A prevalence study conducted in Accra and in a rural area (Bomfo, Ashanti) in 1955 (*6*) showed that in central Accra (analogous to Ablekuma district), during the peak rainy season, parasite rates were 11% in infants and 24% in adults, with a peak of 44% in children 3–4 years old. Parasite rates in rural Bomfo were similar but were higher in the younger age groups. In the Danfa Project area, within which Berekuso is located, a longitudinal prevalence study showed parasite rates in the 0–11-year age group ranging from 30% in November 1973 to 18% in October 1974 and 12% in June 1975 (*7*). In the present survey, the same age group exhibited a similar prevalence of 22% in October–November 1978 in Berekuso, but only 2% in urban Ablekuma.

The degree of parasitaemia we observed in Berekuso village was less than that reported in other recent surveys of rural sub-Saharan Africa (*8*, *9*). Seasonal variation in sampling may have played a role in the observed differences. However, the lower parasite rates in rural Berekuso may be largely attributable to the periodic access of its population to the mobile health unit of the Danfa Rural Health Project. The unexpectedly low parasite rate in urban Ablekuma district in the present survey, compared with the surveys in 1955 and 1964–65, may be attributed to a number of factors including the increasingly widespread use of antimalarial drugs for prophylaxis and greater use of personal antimalarial measures. This is most likely a result of a generally greater awareness and appreciation of malaria as a disease entity and more widespread knowledge about its prevention among the more urbanized and better educated population of Ablekuma.

One of the most important findings of this study was that a large proportion of children from urban

Table 4. Episodes of febrile illness and antimalarial practices among residents of Ablekuma and Berekuso (data obtained from questionnaire)

Subject	Ablekuma (%)	Berekuso (%)
No. of febrile episodes in past 2 months	(399)[a]	(135)
0	61	57
1	24	27
2	6	9
3	2	4
4	1	1
Unknown	5	2
Drugs taken to treat febrile illness	(346)	(136)
Chloroquine	64	97
Other antimalarials	1	0
Analgesics/antipyretics	22	0
Herbal drugs	2	1
None	1	2
Unknown	11	0
Antimalarial drugs used for prophylaxis	(408)	(136)
Yes	37	3
No	63	97
Type of prophylactic drug	(130)	(4)
Chloroquine	91	100
Other	9	0
Frequency of use of prophylaxis	(121)	(4)
Regular and appropriate	77	100
Irregular	23	0
Use of antimosquito coils in bedroom	(393)	(138)
Never	16	100
Occasionally	32	0
Often	3	0
Daily	49	0
Use of antimosquito bed-nets	(318)	(127)
Yes	9	0
No	91	100

[a] Figures in parentheses give total number of persons answering the question.

Ablekuma district (40%) had no detectable antibodies against any of the three prevalent malaria species. Also, it is apparent that the rural population acquire antibodies to malaria significantly earlier, and attain higher titres than children from Ablekuma.

Differences in the intensity of transmission may partly account for the different patterns of antibody response in the two localities. On the other hand, the widespread use of malaria chemoprophylaxis in Ablekuma district could have effectively disturbed the natural acquisition of malaria antibodies. Administration of antimalarial drugs to mothers and infants from birth in the Gambia has been shown to reduce the level of malaria antibodies in the mothers and to prevent acquisition of antibodies in the children (*10*). Also, Onori et al. have recently documented a reduction in humoral immunity to malaria in an endemic region of the United Republic of Tanzania which had been exposed to chloroquine pressure for many years (*11*). The degree to which malaria antibodies protect the individual against clinical malaria is still uncertain (*1*). However, complicated malaria forms, usually resulting from high levels of parasitaemia, are more common in individuals with little or no humoral immunity to malaria. Edozien et al. (*12*) have shown that immunoglobulin from patients with high antimalarial antibody titres does reduce parasitaemia and fever when given to children acutely ill with malaria, and such antibody may be important in limiting the degree of peripheral parasitaemia.

Draper et al. (*13*) have developed a model which uses antibody prevalence to estimate malaria incidence. Using this model and our data about the prevalence of anti-*P. falciparum* antibodies, we estimate the risk of malaria infection to be nearly 100% per year in Berekuso village, but only 15–20% per year in Ablekuma.

This survey has revealed that many children and even some adults resident in the urban zones in endemic malaria areas may have had little experience of malaria despite the presence of the disease in adjacent rural areas. Certainly, the increasingly widespread use of chloroquine and other antimalarial drugs in recent years must have had a significant impact on the disease in many urban areas in endemic regions. There is now a generation of children growing up in urban areas with only occasional malarial infection, who may be at particularly high risk of severe disease. Concern that indiscriminate and widespread use of chloroquine will promote chloroquine resistance in West Africa (*13–15*) must be augmented by the recognition that rapid urbanization of populations in these areas may make them especially vulnerable to malaria. In West Africa, where large-scale vector control measures have been practically abandoned, chemoprophylactic regimes may have to be tailored to maintain antibody levels above a critical protective level, thus avoiding the problem of serious complications while still preventing morbidity and mortality in the target population.

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RÉSUMÉ

LE PALUDISME EN ZONE URBAINE ET RURALE DANS LE SUD DU GHANA:
ENQUÊTE SUR LA PARASITÉMIE, LA PRÉSENCE D'ANTICORPS ET LES MESURES DE LUTTE ANTIPALUDIQUE

En octobre et novembre 1978, on a procédé à une enquête sur la parasitémie et la présence d'anticorps antipaludiques dans une population échantillon sélectionnée dans une zone urbaine d'Accra (Ghana) et, simultanément, à une enquête dans un village situé à 60 kilomètres au nord d'Accra, en employant la même méthodologie. Une parasitémie, à *Plasmodium falciparum* dans tous les cas, a été décelée chez 1,6% seulement des 147 citadins examinés. Parmi les enfants de 1 à 10 ans, 40% étaient dépourvus d'anticorps décelable contre ce parasite, cette proportion n'étant que de 7% chez les adultes. Sur 137 ruraux examinés, 22 présentaient une parasitémie, à *Plasmodium falciparum* dans tous les cas sauf 1; on a trouvé des anticorps chez 97% des sujets âgés de plus d'un an. Le risque de paludisme a été estimé à environ 100% par an en zone rurale et à 15% seulement en zone urbaine. Ces résultats montrent qu'une fraction importante des enfants des villes grandissent en étant peu exposés au paludisme, même dans une région considérée comme endémique pour cette maladie. Une enquête concomitante sur les mesures de lutte antipaludique utilisées dans les deux groupes a montré que l'emploi des antipaludéens, chloroquine en particulier, était largement répandu à titre prophylactique dans la population urbaine.

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