TRANSACTIONS OF THE ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (1997) 91, 166–170

Incidence of clinical malaria in pregnant women exposed to intense perennial transmission

N. Diagne[1], C. Rogier[2], B. Cisse[2] and J. F. Trape[1] [1]*Laboratoire de Paludologie, ORSTOM, B.P. 1386, Dakar, Sénégal;* [2]*Service d'Epidémiologie, Institut Pasteur, B.P. 220, Dakar, Sénégal*

Abstract

The interaction between pregnancy and malaria attacks was investigated from 1990 to 1994 among women in the village of Dielmo, a holoendemic area in Senegal where malaria transmission is intense and perennial. Clinical and parasitological data collected during the daily follow-up of 48 pregnancies among 31 women were compared with those collected from the same women using the same methods during the year which preceded or followed their pregnancy. The parasite prevalence, mean and maximum parasite density in *Plasmodium falciparum* infections were significantly higher during pregnancy. The incidence rate of malaria attacks was, on average, 4·2 times higher during pregnancy than during the control period. Although most pregnancies were not associated with a malaria attack and the incidence of malaria attacks decreased as the number of previous pregnancies increased, a significant increase in risk of malaria attacks among multigravidae was noted until the fifth pregnancy.

Keywords: malaria, *Plasmodium falciparum*, pregnancy, prevalence, incidence

Introduction

Numerous studies have investigated the interaction between malaria and pregnancy (see reviews by BRABIN, 1991 and MENENDEZ, 1995). Where malaria is epidemic or of low endemicity, it is responsible for increased rates of severe disease, abortion, foetal death and premature delivery of infants. The effects of malarial infection appear much less marked in highly endemic areas, where adult women have acquired, through repeated prior infections, substantial protective immunity towards the disease (MCGREGOR *et al.*, 1983). In these areas, nearly all studies have demonstrated increased susceptibility of pregnant women to malaria infection. However, although parasite prevalence and density are higher in pregnant than in non-pregnant women, most infections remain asymptomatic and the only clearly established beneficial effects of malaria chemoprophylaxis during pregnancy are to reduce maternal anaemia and increase birth weight in primigravidae (FLEMING *et al.*, 1986; GREENWOOD *et al.*, 1989, 1994; BRABIN, 1991; COT *et al.*, 1992, 1995; GARNER & BRABIN, 1994). To what extent pregnancy is associated with an increase of the incidence of malaria attacks in women living in highly endemic areas has never been documented. Here we report longitudinal observations on the relationship between pregnancy and malaria morbidity in a cohort of women living in a holoendemic area of Senegal. The findings suggest that, although most women do not present a malaria attack during pregnancy, the risk of developing an attack increases considerably during pregnancy, both in primigravidae and multigravidae.

Patients and Methods

Study population and data collection

The study was undertaken from June 1990 to December 1994 in the village of Dielmo, Senegal, with 250 inhabitants, where malaria is holoendemic with intense perennial transmission. The whole population of this village was involved in a prospective study described in detail elsewhere (TRAPE *et al.*, 1994; ROGIER & TRAPE, 1996). Each villager was visited daily at home for clinical monitoring. Thick blood films were prepared and detailed medical examinations were made in all cases of fever. Standardized cards were completed for each illness episode, recording physical findings, investigations carried out, treatment given, and response to treatment. At the beginning of the study, each villager was given a series of biological tests including basic haematology, blood group determination, haemoglobin electrophoresis, and tests for glucose-6-phosphate dehydrogenase (G6PD) deficiency. In addition, during the study period, basic haematology was assessed yearly and thick blood films were prepared monthly from all participants.

Among the participants in the study, 31 women aged from 16 to 41 years presented a total number of 48 pregnancies between June 1990 and December 1994 (one pregnancy in 14 women and 2 pregnancies in 17). For each of these women, the clinical, parasitological and biological data collected during pregnancy were compared with those collected during the year that followed delivery or the year which preceded the assumed date of conception. When 2 control periods could have been used (before or after pregnancy) one was selected at random. Conception was arbitrarily assumed to have occurred 9 months before delivery. Data collected during pregnancy and those collected during the control period were paired monthly for each woman. For instance, if the sixth month of pregnancy was January 1993, the control data used for this month were those collected in January 1992 or January 1994.

None of these women took antimalarial chemoprophylaxis. During pregnancy all cases of fever associated with a malaria parasite:leucocyte ratio ≥0·5 in the thick blood film were systematically treated with quinine (Quinimax®). Outside pregnancy periods, or in cases with a parasite:leucocyte ratio <0·5 among pregnant women, another thick blood film was taken the next day if fever persisted. Whether or not to administer antimalarial treatment was decided by a doctor permanently present in the village, taking into account all the clinical, biological and epidemiological data concerning the patient.

All thick blood film readings were standardized. A total of 200 oil-immersion microscope fields was examined on each slide (about 0·5 µL of blood). The ratio of trophozoites to leucocytes was established separately for each *Plasmodium* species, either by counting the trophozoites until 200 leucocytes had been observed (if the ratio was ≥0·01) or from the total number of trophozoites observed in 200 fields and an estimate of the average number of leucocytes per microscope field (if the ratio was <0·01). For the present analysis, we considered as a *P. falciparum* malaria attack any case of fever (axillary temperature ≥37·5°C) or fever-related symptoms associated with a parasite:leucocyte ratio higher than an age-dependent threshold identified in this population (ROGIER *et al.*, 1996). The threshold level varied from 1·15 parasites per leucocyte at the age of 16 years to 0·59 parasite per leucocyte at the age of 41 years.

The level of malaria transmission in Dielmo was esti-

Address for correspondence: Dr J. F. Trape, ORSTOM, B.P. 1386, Dakar, Sénégal; phone +221 32 09 62, fax +221 32 16 75, e-mail trape@belair.orstom.sn

mated from night-time biting collections of mosquitoes (TRAPE *et al.*, 1994; FONTENILLE *et al.*, in press). For each woman the levels of exposure to transmission during pregnancy and the control period were calculated from monthly estimates of the entomological inoculation rate.

Statistical analysis

We used a generalized estimating equation approach (ZEGER & LIANG , 1986) for statistical analysis of repeated measures, which can be used with normal, binomial and Poisson distributions, and is available as a statistical package (SPIDA® version 6, Statistical Computing Laboratory, Eastwood, New South Wales, Australia; 1992). We used an exchangeable correlation structure in which the correlation between observations made on the same person at different times is assumed to be the same. The differencies were tested by the Wald test and 95% confidence intervals (95% CI) were calculated. The equivalence of transmission levels within each pair of pregnant and control survey periods was tested by analysis of variance for repeated measures. The malaria morbidity, incidence and density were analysed using a link function for a Poisson distribution response and the number of days under survey as the exposure variable. The parasite prevalence was analysed as a binomial distribution response, and the parasite density in parasitaemic persons as a normally distributed response. The dispersion parameter was used to estimate the goodness of fit and the common correlation was estimated.

The effects of age and number of previous pregnancies were tested as numerical variables. The effects of absence from Dielmo during the years preceding the observation period, G6PD deficiency, sickle cell trait, and ABO or rhesus blood group were also tested for and taken into account in multivariate analysis.

Results

Duration of monitoring

The duration of monitoring amounted, on average, to 8·1 months per woman during pregnancy and 8·6 months per woman during the control period. Women were monitored daily during pregnancy for 9 months in 31 cases. In 17 cases monitoring during pregnancy was not continuous, since 8 of these women were already pregnant when the survey was started and 9 women were absent from Dielmo for a maximum of 2 months.

Table 1. Malaria parasite rates during pregnancy and the control period

Period	*P. falciparum*	*P. malariae*	*P. ovale*	Total
Pregnancy	56·2%	3·8%	0·5%	57·8%
Control	39·5%	5·6%	0·5%	43·5%

Parasite prevalence and density

A total of 791 routine thick blood films was prepared monthly, 374 during pregnancy and 417 during the control period, i.e. 7·8 and 8·7 thick blood films per woman, respectively, for each of the 2 periods of 9 months. Two hundred additional thick blood films were prepared during episodes of illness, 111 during pregnancy and 89 during the control period.

Monthly pairing of the routine thick blood films made during pregnancy with those made in the control period was possible in 372 cases. The mean parasite prevalence was 57·8% during pregnancy and 43·5% during the control period ($P<0·001$); most of the infections were due to *P. falciparum* (Table 1). For each trimester of pregnancy, the mean prevalence of *P. falciparum* infection was higher than in the corresponding control trimester (Table 2). Mean parasite densities in asymptomatic *P. falciparum* infections were significantly higher in each of the 3 trimesters of pregnancy than in the corresponding control trimester (Table 2).

In 31 of the 48 pregnancies (64·6%), the mean parasite rate during pregnancy was higher than that during the control period. It was identical in 11 pregnancies (22·9%), and lower in 6 (11·5%). In 39 of the 48 pregnancies (81·2%), the mean parasite densities in asymptomatic *P. falciparum* infections were higher than those in the control period; they were lower in the remainder. The maximum parasite density, whether associated or not with the occurrence of symptoms, occurred during pregnancy in 37 cases (77·1%) and during the control period in the remaining 11 (22·9%).

Malaria morbidity

During the 48 pregnancies, 30 episodes of fever were noted, of which 14 were attributable to malaria. In 63 other pathological episodes without detected hyperthermia, 5 were ascribed to malaria because they presented a parasite density higher than the diagnostic threshold associated with symptoms related to fever: reported fever (5 cases), headache (5 cases), and vomiting (3 cases). The 19 cases of malaria attacks noted during pregnancy occurred in the first trimester in one case, in the second trimester in 7 cases, and in the third trimester in 11 cases (9 of which occurred in the last 2 months). All malaria attacks were mild and were rapidly cured within one or 2 d.

During the 48 control periods, 25 episodes of fever were noted, of which 3 were attributable to malaria. In 40 other pathological episodes without detected hyperthermia, 2 episodes were also ascribed to malaria as they presented a parasite density higher than the diagnostic threshold associated with fever-related symptoms (headache, asthenia, reported fever). The 5 cases of ma-

Table 2. Prevalence and density of *Plasmodium falciparum* infections according to trimesters of pregnancy and control periods

	1	2	3	Total
Number	112	128	132	372
Parasite rate				
Pregnancy	58·9%	59·4%	50·8%	56·2%
Control	37·5%	37·5%	43·2%	39·5%
Mean parasite density[a]				
Pregnancy				
Geometric	0·6 (0·3–1·0)	1·2 (0·8–1·8)	1·3 (0·8–1·9)	1·1 (0·8–1·4)
Arithmetic	2·8 (1·0–4·6)	6·7 (2·2–11·2)	7·7 (4·1–11·2)	6·0 (3·9–8·1)
Control				
Geometric	0·3 (0·2–0·5)	0·4 (0·2–0·6)	0·4 (0·2–0·6)	0·4 (0·3–0·5)
Arithmetic	1·1 (0·4–1·8)	1·7 (0·6–2·7)	1·9 (0·7–3·0)	1·5 (1·0–2·1)

[a]Mean number of trophozoites per 100 leucocytes in asymptomatic subjects only; thick blood films associated with the occurrence of hyperthermia or fever-related symptoms within 72 h before or after sampling were excluded; 95% confidence intervals are shown in parentheses.

Table 3. Characteristics of the study population

Age (years)	Parity	Follow-up (no. of days) Pregnancy	Control	No. of malaria attacks Pregnancy	Control
16	1	173	241	1	–
18	1	273	243	–	–
16[a]	1	271	273	2	1
17[a]	1	221	217	1	–
26	2	52	258	–	–
20	2	216	202	–	–
20	2	252	256	1	–
16	2	81	254	–	–
23[a]	2	275	274	–	–
19	2	230	273	–	–
19[a]	2	273	273	1	–
29	3	275	275	–	–
23	3	275	274	–	–
20	3	273	274	1	–
24	3	258	274	1	–
23	3	202	275	–	–
18	3	275	275	–	–
28	3	268	218	2	–
24[a]	3	270	260	–	–
20	3	274	273	–	–
25	4	274	274	1	–
22	4	273	274	1	–
39	4	270	239	–	–
26	4	44	263	–	–
23	4	275	269	–	–
31	4	274	274	–	–
23	4	176	273	–	–
23	4	273	274	1	1
30	4	62	269	2	–
31	4	208	268	–	1
29	5	273	274	–	1
32	5	274	270	–	–
26	5	267	275	–	–
30[a]	5	175	256	2	–
26	5	273	273	1	–
34	5	276	276	–	–
33	6	273	274	–	–
24	6	271	215	–	–
26	6	266	276	–	–
28	7	273	272	–	–
35	7	274	273	1	–
35	7	275	237	–	–
32	8	273	273	–	–
39	8	273	274	–	–
37	8	272	267	–	1
37	8	270	268	–	–
41	9	273	274	–	–
39	9	274	272	–	–

[a]Women who had lived for more than half of their life in a hypoendemic area.

laria attacks noted during the control period occurred in the first trimester in 2 cases, in the second trimester in 2 cases, and in the third trimester in one case. These attacks were mild and fever lasted less than one day.

The characteristics of the study women and details of their individual malaria attacks are shown in Table 3. Eighteen of the 31 women had no malaria attack during either pregnancy or the control period; 8 women had one or more attacks during pregnancy only, 2 during the control period only, and 3 during both pregnancy and the control period. The 4 primigravidae in the study had a total of 4 malaria attacks during their pregnancies and only one attack during the control period. The 44 pregnancies among multigravidae were associated with 15 malaria attacks during pregnancy and 4 during the control period. Of 36 pregnancies monitored daily for at least 250 d, 25 (69%) were not associated with malaria attacks.

Anaemia

The yearly routine clinical tests coincided with a period of pregnancy in 32 cases and with a control period in 27 cases. The mean haemoglobin level was 10·6 (10·2–11·1) g/dL during pregnancy and 11·7 (11·1–12·3) g/dL during the control periods ($P<0·01$). No case of anaemia with haemoglobin <8 g/dL was observed among the study women during pregnancy or the control period.

Multivariate analysis

There was no difference in the intensity of *P. falciparum* transmission between the periods of pregnancy (152·3±13·7 infective bites) and the control periods (157·0±13·6 infective bites). Excluding the periods of 7 d following antimalarial treatment, the total number of follow-up days amounted to 11437 for the 48 periods of pregnancy and 12391 for the 48 control periods. The incidence density rate of malaria attacks was 0·166 per 100 person-days (95% CI 0·100–0·259) during pregnancy, i.e. one malaria attack every 1·7 years, and 0·040 per 100 person-days (95% CI 0·013–0·094) during the control period, i.e. one every 6·8 years. The incidence density rate of malaria attacks during the pregnancy periods decreased with increasing number of previous pregnancies from 0·443 per 100 person-days (95% CI 0·120–1·133) among primigravidae to 0·208 per 100 person-days (95% CI 0·107–0·363) among the women who had had 1–3 pregnancies in the past and 0·063 for 100 person-days (95% CI 0·013–0·184) among women who had 4 or more pregnancies. During the control periods there was no significant decrease in the incidence of malaria attacks with the number of previous pregnancies.

Accounting for the correlation among the repeated observations for a given person and for the effects of age, G6PD deficit, previous absence from Dielmo, and blood group, the incidence density rate of malaria attacks increased significantly during pregnancy ($P<0·005$) and the rate during pregnancy decreased with increasing number of previous pregnancies ($P=0·08$). Taking the control periods as the reference group, the incidence density ratio was 9·2 (95% CI 2·2–38·1) among primigravidae, 6·9 (95% CI 2·2–22·6) among gravidae 2, 5·3 (95% CI 2·0–13·9) among gravidae 3, 4·0 (95% CI 1·7–9·3) among gravidae 4, 3·0 (95% CI 1·2–6·9) among gravidae 5, and 2·3 (95% CI 0·9–5·7) among gravidae 6 or more. Excluding primigravidae from the analysis, and again taking the control periods as the reference group, the incidence density ratio was 8·8 (95% CI 2·8–27·1) among gravidae 2, 6·2 (95% CI 2·3–16·7) among gravidae 3, 4·3 (95% CI 1·7–10·7) among gravidae 4, 3·0 (95% CI 1·3–7·3) among gravidae 5, and 2·1 (95% CI 0·8–5·3) among gravidae 6 or more. This decrease of the incidence density ratio with increasing numbers of previous pregnancies was significant ($P<0·005$).

There was no significant effect of age, sickle cell trait, or blood group in addition to the effect of number of previous pregnancies. G6PD deficiency decreased the incidence rate of malaria attacks during pregnancy and control periods by 2·1 times (95% CI 1·1–4·1) and absence from Dielmo for more than one year during the 3 years preceding the survey period increased it by 2·6 times (95% CI 1·1–5·8). The estimated dispersion parameter (1·02) indicated a satisfactory fit and the overall correlation within subjects (0·06) suggested that the repeated observations could be considered as independent.

Discussion

It is well established that the prevalence of *P. falciparum* infections increases among pregnant women liv-

ing in highly endemic areas, and this was also observed in our study. A negative thick blood film in a highly endemic area is of only limited significance, since in most cases it reflects merely the existence of parasitaemia lower than the threshold of detection by standard microscopical examination (TRAPE, 1985). With the Dielmo villagers, analysis by polymerase chain reaction (PCR) of selected blood samples showed that the actual prevalence of *P. falciparum* among adults in cross-sectional surveys was about 90% (BOTTIUS *et al.*, 1996). This suggests that the apparent increase of malaria prevalence during pregnancy in Dielmo merely reflected the fact that a higher proportion of malaria infections had reached the threshold of detectability in a thick blood film.

A significant increase of parasite density was observed among Dielmo women in each trimester of the pregnancy period. This increase was more marked during the second trimester than during the first, as previously observed in other studies (BRABIN, 1983, 1991). However, in contrast to these studies, the increase remained noticeable in the third trimester. In our survey the increased incidence of malaria attacks led to more antimalarial treatments being given during the second and third trimesters of the pregnancy period than during the first trimester of pregnancy and the corresponding control periods. However, analysis of individual data suggested that, overall, these treatments did not greatly affect the differences of prevalence and parasite density noted between each trimester of pregnancy and the corresponding control periods.

It is generally acknowledged that, in areas of high endemicity, the increased susceptibility of pregnant women to malaria infection has little clinical consequence, at least among multigravidae (MENENDEZ, 1995). Our observations showed that, even among women exposed since birth to intense perennial transmission, the incidence of malaria attacks increased greatly during pregnancy. An average increase by a factor of 4 was noted not only among primigravidae but also among multigravidae, who represented more than 90% of our study population. The rate of increase of the incidence of malaria attacks during pregnancy decreased with the number of previous pregnancies, but it remained sufficiently large even in the fifth pregnancy to be statistically significant in spite of the small number of women enrolled in our study.

Do our observations justify recommending chemoprophylaxis for all pregnant women living in endemic areas? The spread of chloroquine resistance has led to reconsideration of the role of chemoprophylaxis in malaria control (WHO, 1992). In highly endemic areas, chemoprophylaxis is recommended for primigravidae who constitute a high risk group for anaemia and low birth weight (GILLES *et al.*, 1969; GARNER & BRABIN, 1994; GREENWOOD *et al.*, 1994; COT *et al.*, 1995), but it now tends to be abandoned for multigravidae and other risk groups including infants who are even more liable than their mothers (even the primigravidae) to fatal complications of malaria. In Dielmo, where malaria transmission is perennial and varies from about 100 to 300 infective bites per person per year (KONATÉ *et al.*, 1994; FONTENILLE *et al.*, in press), the incidence of malaria attacks is maximal in children 1–3 years of age who have about 5 malaria attacks per year. It decreases rapidly afterwards, to reach low levels among adolescents and adults who have about one malaria attack every 3–7 years (TRAPE & ROGIER, 1996). The mean incidence rate of malaria attacks among pregnant primigravidae in Dielmo was similar to that observed among children from the same village aged 7–8 years and among multigravidae it was similar to that seen in children aged 10 years. In this context, the increased incidence of mild malaria attacks during pregnancy would not justify, by itself, chemoprophylaxis being reserved for pregnant women only.

Acknowledgements

We are grateful to the women of Dielmo for active participation and continuing collaboration with the project. We also acknowledge the contribution of B. Canque, A. Tall, D. Fontenille, L. Konaté, C. Sokhna, F. Faye, A. Badji, H. Bouganali and G. Ndiaye in data collection, and we thank L. Pereira da Silva, P. Druilhe, O. Mercereau-Puijalon and C. Grillot-Courvalin for encouragement and advice.

This work was supported by grants from the French *Ministère de la Coopération* and *Ministère de la Recherche et de l'Enseignement Supérieur.*

References

Bottius, E., Guanzirolli, A., Trape, J.-F., Rogier, C., Konaté, L. & Druilhe, P. (1996). Malaria: even more chronic in nature than previously thought; evidence for subpatent parasitaemia detectable by the polymerase chain reaction. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 90, 15–19.

Brabin, B. J. (1983). An analysis of malaria in pregnancy in Africa. *Bulletin of the World Health Organization*, 61, 1005–1015.

Brabin, B. J. (1991). *The risks and severity of malaria in pregnant women.* Geneva: World Health Organization, Applied Field Research in Malaria Reports, TDR/FIELDMAL/1.

Cot, M., Roisin, A., Barro, D., Yada, A., Verhave, J. P., Carnevale, P. & Breart, G. (1992). Effect of chloroquine chemoprophylaxis during pregnancy on birth weight: results of a randomized trial. *American Journal of Tropical Medicine and Hygiene*, 46, 21–27.

Cot, M., Le Hesran, J. Y., Miailhes, P., Esveld, M., Etya'ale, D. & Breart, G. (1995). Increase of birth weight following chloroquine chemoprophylaxis during the first pregnancy: results of a randomized trial in Cameroon. *American Journal of Tropical Medicine and Hygiene*, 53, 581–585.

Fleming, A. F., Ghatoura, G. B. S., Harrison, K. A., Briggs, N. D. & Dunn, D. T. (1986). The prevention of anaemia in pregnancy in primigravidae in the guinea savanna of Nigeria. *Annals of Tropical Medicine and Parasitology*, 80, 211–233.

Fontenille, D., Lochouarn, L., Diagne, N., Sokhna, C., Lemasson, J. J., Diatta, M., Konaté, L., Faye, F., Rogier, C. & Trape, J. F. (in press). High annual seasonal variations in malaria transmission by *Anopheles* and vector species composition in Dielmo, a holoendemic area in Senegal. *American Journal of Tropical Medicine and Hygiene.*

Garner, P. & Brabin, B. J. (1994). A review of randomized controlled trials of routine antimalarial drug prophylaxis during pregnancy in endemic malarious areas. *Bulletin of the World Health Organization*, 72, 89–99.

Gilles, H. M., Lawson, J. B., Sibelas, M., Voller, A. & Allan, N. (1969). Malaria, anaemia and pregnancy. *Annals of Tropical Medicine and Parasitology*, 63, 245–263.

Greenwood, B. M., Greenwood, A. M., Snow, R. W., Byass, P., Bennett, S. & Hatib-N'jie, A. B. (1989). The effects of malaria chemoprophylaxis given by traditional birth attendants on the course and outcome of pregnancy. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 83, 589–594.

Greenwood, A. M., Menendez, C., Todd, J. & Greenwood, B. M. (1994). The distribution of birth weights in Gambian women who received malaria chemoprophylaxis during their first pregnancy and in control women. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 88, 311–312.

Konaté, L., Diagne, N., Brahimi, K., Faye, O., Legros, F., Rogier, C., Petrarca, V. & Trape, J. F. (1994). Biologie des vecteurs et transmission de *Plasmodium falciparum, P. malariae* et *P. ovale* dans un village de Savane d'Afrique de l'ouest (Dielmo, Sénégal). *Parasite*, 1, 325–333.

McGregor, I. A., Wilson, M. E., & Billewicz, W. Z. (1983). Malaria infection of the placenta in The Gambia, West Africa; its incidence and relationship to stillbirth, birthweight and placental weight. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 77, 232–244.

Menendez, C. (1995). Malaria during pregnancy: a priority area of malaria research and control. *Parasitology Today*, 11. 178–183.

Rogier, C. & Trape, J. F. (1996). Etude de l'acquisition de la prémunition en zones d'holo- et de méso-endémie palustre à Dielmo et à Ndiop (Sénégal): résultats préliminaires, 1990–1994. *Médecine Tropicale*, 55, 71–76.

Rogier, C., Commenges, D. & Trape, J.-F. (1996). Evidence for an age-dependent pyrogenic threshold of *Plasmodium falciparum* parasitemia in highly endemic populations. *American Journal of Tropical Medicine and Hygiene*, 54, 613–619.

Trape, J. F. (1985). Rapid evaluation of malaria parasite density and standardization of thick smear examination for epidemiological investigations. *Transactions of the Royal Society of*

Tropical Medicine and Hygiene, 79, 181–184.
Trape, J. F. & Rogier, C. (1996). Combating malaria morbidity and mortality by reducing transmission. *Parasitology Today*, 12, 236–240.
Trape, J. F., Rogier, C., Konaté, L., Diagne, N., Bouganali, H., Canque, B., Legros, F., Badji, A., Ndiaye, G., Ndiaye, P., Brahimi, K., Faye, O., Druilhe, P. & Pereira Da Silva, L. (1994). The Dielmo project: a longitudinal study of natural malaria infection and the mechanisms of protective immunity in a community living in a holoendemic area of Senegal. *American Journal of Tropical Medicine and Hygiene*, 51, 123–137.
WHO (1992). Malaria: ministerial conference on malaria, Amsterdam. *Epidemiological Record*, 47, 349–350.
Zeger, S. L. & Liang, K. (1986). Longitudinal data analysis for discrete and continuous outcomes. *Biometrics*, 42, 121–130.

Received 17 June 1996; revised 4 October 1996; accepted for publication 8 October 1996

Announcements

African Index Medicus (AIM) Project
An International Index to African health literature and information sources

In order to give access to information published in or related to Africa and to encourage local publishing, the Association for Health Information and Libraries in Africa (AHILA), with the technical support of the World Health Organization, has initiated a project to create an international index to African Health literature and information sources—the *African Index Medicus*.

The creation of the regional index is a collaborative, participatory process. Firstly, national databases are being built, using a common methodology, in African countries. From them, local information services and products will be provided for national health professionals. National production should ensure self-sufficiency and sustainability at country level and the tailoring of services according to local needs.

The various national databases are then merged into a regional data base to which are added bibliographic records relating to health in Africa from other international existing sources such as WHO's WHOLIS, MEDLINE, POPLINE etc. to produce the *African Index Medicus* in printed or electronic form, eventually CD-ROM. It is distributed to African countries as part of an affiliated membership to AHILA for institutions outside the region.

At this stage, AHILA, with support from WHO, is looking for further sponsoring partners at bilateral level with African countries not yet participating in the Project. Sponsorship comprises equipment and training of staff and could be part of an information component of a health related project in the country, which may also include use of communications and CD-ROM.

Further information can be obtained from Dr Deborah Avriel, World Health Organization, Library, 1211 Geneva 27, Switzerland; fax +44 22 791 0746.

Low Priced Publications from Tropical Health Technology

Students and medical workers from developing countries can purchase medical books and laboratory learning aids from Tropical Health Technology at reduced prices, including the new editions of:
Manson's Tropical Diseases, 20th edition
Color Atlas of Tropical Medicine and Parasitology, 4th edition
Lecture Notes on Tropical Medicine, 4th edition.

Also available are other up to date textbooks covering tropical paediatrics, epidemiology, cardiology, nursing, midwifery, laboratory sciences, and solar energy. Training materials include laminated colour photomicrographs with text covering the microscopical diagnosis of tropical disease.

A publications list with prices (inclusive of postage) and order form can be obtained from Tropical Health Technology, 14 Bevills Close, Doddington, March, PE15 0TT, UK; fax: +44 (0)1354 740 013, phone: +44 (0)1354 740 825.