Malaria in late pregnancy in Al Hodeidah governorate, Yemen

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الإصابة بالملاريا في أواخر الحمل في محافظة الحديدة باليمن

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الخلاصة: بغية استقصاء نتائج الإصابة بالملاريا في أواخر الحمل، أجرى الباحثان دراسة مبدئية في مستشفيين في محافظة الحديدة، على 276 امرأة وَلَدْنَ ولادات مهبلية دون مضاعفات. وكانت 17 امرأة فقط من بين هؤلاء مصابات بالملاريا (المتصورة المنجلية *Plasmodium falciparum*)، ستٌّ منهن وجدت فيهن الطفيليات في الدم و11 وجدت فيهن الطفيليات في الدم إلى جانب الملاريا المشيمية. وقد مثلت العدوى العارضة اختطاراً يزيد بمقدار 9.44 ضعفاً لحدوث ولادات مبتسرة، واختطاراً يزيد بمقدار 12.2 ضعفاً لنقص وزن الجنين (<2500 غ). وقد شخصت الإصابة بفقر الدم في 46.4٪ من الحالات، وكانت مرتبطة بالملاريا في 11.7٪ منها، وكانت جميع عوامل الاختطار، كالإقامة في المناطق الريفية (نسبة الأرجحية 5.18)، وعمر الأم <20 سنة (نسبة الأرجحية4.39) والحمل الأول (نسبة الأرجحية 8.29) جميعها مرتبطة بشكل كبير بعدوى الملاريا.

ABSTRACT To investigate the consequences of maternal malaria during late pregnancy, we conducted a preliminary study in the 2 hospitals in Al Hodeidah on 276 women who had uncomplicated vaginal deliveries. Only 17 women had malaria (***Plasmodium falciparum***), 6 with peripheral parasitaemia and 11 with both peripheral parasitaemia and placental malaria. Coincident infection carried a 9.44 times higher risk of preterm delivery and a 12.2 times greater risk of low birth weight (< 2500 g). Anaemia was diagnosed in 46.4%, associated with malaria in 11.7 % of cases. All risk factors, rural residence (OR 5.18), maternal age < 20 years (OR 4.93) and primigravidae (OR 8.29), were significantly associated with malaria infection.

Le paludisme en fin de grossesse dans le Gouvernorat d'Al Hodeidah (Yémen)

RÉSUMÉ Afin d'examiner les conséquences du paludisme maternel durant le dernier trimestre de la grossesse, nous avons réalisé une étude préliminaire dans les deux hôpitaux de Al Hodeidah sur 276 femmes qui avaient eu un accouchement par voie basse sans complications. Seules 17 femmes avaient le paludisme (***Plasmodium falciparum)***, 6 présentant une parasitémie périphérique et 11 ayant à la fois une parasitémie périphérique et un paludisme placentaire. La présence concomitante de ces deux paramètres d'infection comportait un risque 9,44 fois plus élevé d'accouchement prématuré et un risque 12,2 fois plus élevé de faible poids de naissance (< 2500 g). Une anémie a été diagnostiquée chez 46,4 %, en association avec le paludisme chez 11,7 % des cas. La résidence rurale (OR 5,18), l'âge de la mère inférieur à 20 ans (OR 4,93) et le statut de primigeste (OR 8,29) étaient les facteurs de risque significativement associés à l'infection paludéenne.

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Introduction

Malaria is a priority public health problem in Yemen. The problem has become more acute with the emergence of *Plasmodium falciparum* strains resistant to chloroquine. About 60% of the total population of 20 million is at risk [*1*]. The estimated number of cases was up to 3 million in the year 2000, more than 90% of them *P. falciparum* malaria. *Anopheles arabiensis* is the main vector of transmission [*2*].

Falciparum malaria is known to adversely affect the feto-placental unit, especially during the last trimester, and LBW babies born to mothers with malaria infection are probably the product of a pathological process [*3*]. Malaria infection affects birth weight through placental hyperparasitism [*4*] or indirectly through malaria-induced maternal anaemia [*5*].

In Yemen, mothers and children constitute a priority group. Together they form nearly two thirds of the total population [*6*]. Yemen is experiencing very rapid population growth compared with other developing countries: women marry by 15 years of age and conceive during their teenage years [*7*]. Maternity care is still minimal. High maternal (100/10 000 live births, 1991) and infant (78.8/1000 live births, 1998) mortality rates have been recorded [*8*].

In neonates, the mortality rate of Yemeni infants considered by their mothers to be smaller than average at birth was nearly 3 times that of infants estimated to be normal sized at birth. In early childhood, it was still 1.5 times that of infants considered normal sized at birth [*7*]. The overall rate of low-birth-weight infants (birth weight < 2500 g) in Yemen was 47% in 1994 [*8*].

Malaria infection in pregnancy has not previously been studied in Yemen. In particular, there is no data in terms of its impact on the health of both mother and baby. Clinical observations have indicated that symptoms are more severe in mothers, but little is known about the effect of placental malaria on the newborn baby.

We conducted a preliminary study in Al Hodeidah governorate in order to investigate the consequences of maternal malaria during late pregnancy and the effect of placental malaria on survival and morbidity of neonates. This information will help in the formulation and implementation of a malaria control strategy for pregnant women in Yemen.

Methods

The study area was Al Hodeidah governorate in western Yemen. According to the 1998 census, this area is inhabited by 10% of the total Yemeni population.

We conducted a cross-sectional descriptive study on all women who had uncomplicated vaginal deliveries in the labour wards of the 2 hospitals in the study area, Al Thawra (n = 227) and Asalakhana (n = 49), during March–August 2001. After consent was obtained from the mothers, they were interviewed by the supervising physician in the labour ward. Data concerning personal and obstetric history, the current pregnancy and pregnancy outcome were collected.

A peripheral maternal blood smear was made by finger prick. A cord smear was prepared from the blood of the umbilical stump. A placental smear was taken from the blood on the maternal side of the placenta after an incision had been made. Duplicate thin and thick blood films were stained with Giemsa stain and examined microscopically for malaria parasites. Parasites were counted against 200 leukocytes and expressed as number of parasites/µL blood, assuming a standard leukocyte count of 8000/µL blood [*9*]. A second investigator, blind to the initial results, re-

checked all positive and 10% of randomly chosen negative slides. Maternal haemoglobin (Hb) level was measured using the cyanmethaemoglobin photometric method [*10*]. Haemoglobin concentration ≥ 10g/dL was considered normal [*11*]. Packed cell volume was estimated by the microhaemocrit centrifugation method. The red blood cell count ($\times 10^6/\mu L$) was also done by automated blood counting and blood indices calculated [*10*].

Birth weight was measured soon after birth using digital scales.

All questionnaires were reviewed prior to computer data entry. Data were analysed using *SPSS,* version 9.0. Proportion was used to present qualitative data. Geometric mean and standard deviation were used for calculating quantitative data such as parasite density and blood parameters and indices. To compare proportions and to estimate the difference in risk between groups, odds ratios and 95% confidence intervals were calculated. For comparison of mean blood parameters and indices of malaria infection, analysis of variance was applied followed by least significant difference. *P*-value < 0.05 was used as indicator of statistical significance.

Results

Table 1 shows some demographic and medical data about the mothers and neonates in this study. Of the 276 pregnant women who participated in the study, 23.9% were from rural areas, 29.7% were under 20 years old at the time of the study, 46.0% had given birth before the age of 20 years and 80.8% were married when they were under 20 years old. Most of the study participants (85.5%) were housewives, 29.0% were primigravidae and 90.2% had full term deliveries (> 37 weeks).

Table 1 **Principal characteristics of the study sample**

Characteristic	No.	%
Age at marriage (years)		
< 20	223	80.8
20 +	53	19.2
Age at delivery (years)		
< 20	127	46
20 +	149	54
Maternal education		
Illiterate	196	71.0
Primary & preparatory school	26	9.4
Secondary school & university	54	19.6
Maternal occupation		
Housewife	236	85.5
Employed	40	14.5
Gestational age		
Full term (≥ 37 weeks)	249	90.2
Preterm (< 37 weeks)	27	9.8
Antimalarial drugs used during current pregnancy		
Yes	73	26.4
Chloroquine	52	71.2
Chloroquine + pyrimethamine	13	17.8
Sulfadoxine + pyrimethamine	8	11.0
No	203	73.6
No. of antenatal care visits during current pregnancy		
None	95	34.4
1	70	38.7
2	47	26.0
3	26	14.4
4	38	21.0
Total	181	65.6

Coincident infection was found in 8/11 women from rural areas (72.7%) and 3/11 women from urban areas (27.3%). Prevalence of primigravidae was 54.5% in the women from rural areas and 9.1% in those from urban areas (data not shown in tables).

No anti-malarial drugs had been given for 73.6% of the women, either for treatment or prophylaxis, and 34.4% had not visited antenatal care clinics during the current pregnancy.

All babies were live singleton deliveries. Twenty-nine of them were of low birth weight (LBW) (< 2500 g). Only 17 (6.2%) of the women had malaria, 6 with peripheral parasitaemia alone and 11 with both peripheral parasitaemia and placental malaria. Cord parasitaemia was not detected. *P. falciparum* was the only recorded parasite species. Anaemia (Hb < 10 g/dL) was diagnosed in 46.4% of the women in the study.

Analysis of potential risk factors predisposing to malaria infection among pregnant women revealed that all were significantly associated with malaria infection in the study participants (Table 2). Malaria was significantly more prevalent among participants from rural areas and they were at a 5.18 times greater risk than those from urban areas ($P < 0.05$). Participants in the age group < 20 years showed a 4.93 times higher estimated risk of infection than those in the age group 20–34 years ($P < 0.05$). Primigravidae had an 8.3 times greater risk of infection than secundigravidae ($P < 0.05$).

Malaria infection and parasite density were associated with maternal anaemia. Pregnant women with coincident infection (both peripheral parasitaemia and placental malaria) had a 28.42 times higher risk of maternal anaemia and a 9.44 times greater risk of preterm delivery. They also had a 12.15 times greater risk of having LBW babies than aparasitaemic women (Table 3) ($P < 0.05$).

Similarly, a high parasite density (≥ 1000 parasites/μL blood) carried a 22.27 times higher estimated risk of maternal anaemia, a 14.17 times greater risk of preterm delivery and a 9.45 times higher estimated risk of having LBW babies than women who were aparasitaemic (Table 4) ($P < 0.05$).

Table 2 **Potential risk factors predisposing to malaria infection**

Factor	Aparasitaemia No.	%	Parasitaemia No.	%	Crude OR	95% CI
Residence						
Urban (***n*** = 210)[a]	203	96.7	7	3.3	1.00	
Rural (***n*** = 66)	56	84.8	10	15.2	5.18	1.72–15.92*
Maternal age (years)						
< 20 (***n*** = 82)	73	89.0	9	11.0	4.93	1.17–23.82*
20–34 (***n*** = 123)[a]	120	97.6	3	2.4	1.00	
>34 (***n*** = 71)	66	93.0	5	7.0	3.03	0.61–16.60
Gravidity						
Primigravidae (***n*** = 80)	70	87.5	10	12.5	8.29	1.04–178.05*
Secundigravidae (***n*** = 59)[a]	58	98.3	1	1.7	1.00	
Multigravidae (***n*** = 137)	131	95.6	6	4.4	2.66	0.31–59.88

OR = odds ratio.
CI = confidence interval.
[a]***Reference group.***
****Significant at** P **< 0.05.***

Table 3 **Association between malaria infection (*Plasmodium falciparum*) and maternal anaemia (Hb < 10 g/dL), gestational age at delivery and birth weight**

Variable	Peripheral parasitaemia (*n* = 6)		Peripheral parasitaemia + placental malaria (*n* = 11)		Aparasitaemia (*n* = 259)		Total
	No.	%	No.	%	No.	%	
Haemoglobin							
≥ 10 g/dL	2	1.4	0	0.0	146	98.6	148
< 10 g/dL	4	3.1	11	8.6	113	88.3	128
OR	2.58		28.42*		1[a]		
95% CI	0.04–20.69		1.73–509.17		–		
Gestational age[b]							
Full term	5	2.0	6	2.4	238	95.6	249
Preterm	1	3.7	5	18.5	21	77.8	27
OR	2.27		9.44*		1[a]		
95% CI	0.05–21.58		2.26–39.16		–		
Birth weight of newborn							
NBW	5	2.6	2	1.0	189	96.4	196
LBW	1	1.2	9	11.3	70	87.5	80
OR	0.54		12.15*		1[a]		
95% CI	0.02–4.87		2.37–83.60		–		

Significant at** P **< 0.05.
*[a]**Reference group.***
*[b]**Preterm, < 37 weeks.***
NBW = normal birth weight, ≥ 2500 g; LBW = low birth weight, < 2500 g.
OR = odds ratio; CI = confidence interval.

Of the 276 women who participated in the study, 128 (46.4%) were anaemic (Hb < 10 g/dL), 15 of whom (11.7%) also had malaria parasitaemia. There were 148 (53.6%) non-anaemic women, 2 (1.4%) of whom were parasitaemic (Table 5). Anaemia and parasitaemia in mothers had an effect on gestational age at birth and on birth weight.

Of the 27 women who had preterm deliveries, 22.2% were parasitaemic and anaemic. They had a 3.30 times higher risk of preterm delivery than the women who were aparasitaemic but anaemic ($P > 0.05$). Similarly, women who were parasitaemic but non-anaemic had an 18.00 times higher risk of preterm delivery than those who were aparasitaemic and non-anaemic ($P > 0.05$).

Of 80 women who had LBW babies, 11.2% were parasitaemic and anaemic and had a 3.08 times higher risk of delivering LBW babies than the women who were aparasitaemic but anaemic ($P > 0.05$). Similarly, women who were parasitaemic but non-anaemic had a 3.42 times higher risk of having LBW babies than those who

Table 4 **Association between parasite density (PD) and maternal anaemia (Hb < 10 g/dL), gestational age at delivery and birth weight**

Variable	Parasitaemia				Aparasitaemia		Total
	PD < 1000 (*n* = 8)		PD ≥1000 (*n* = 9)		(*n* = 259)		
	No.	%	No.	%	No.	%	
Haemoglobin							
≥ 10 g/dL	2	1.4	0	0.0	146	98.6	148
< 10 g/dL	6	4.7	9	7.0	113	88.3	128
OR	3.88		22.27*		1[a]		
95% CI	0.69–28.33		1.41–425.84		–		
Gestational age[b]							
Full term	7	2.8	4	1.6	238	95.6	249
Preterm	1	3.7	5	18.5	21	77.8	27
OR	1.62		14.17*		1[a]		
95% CI	0.03–13.60		3.00–69.39		–		
Birth weight of newborn							
NBW	5	2.6	2	1.0	189	96.4	196
LBW	3	3.7	7	8.8	70	87.5	80
OR	1.62		9.45*		1[a]		
95% CI	0.30–8.04		1.74–67.56		–		

Significant at** P **< 0.05.
*[a]**Reference group.***
*[b]**Preterm, < 37 weeks.***
NBW = normal birth weight, ≥ 2500 g; LBW = low birth weight, < 2500 g.
OR = odds ratio; CI = confidence interval.

were aparasitaemic and non-anaemic ($P < 0.05$) (Table 5).

The effect of malaria infection on blood parameters and indices is shown in Table 6. Microcytic hypochromic anaemia was the predominant type of anaemia among the women infected with malaria. Those with peripheral parasitaemia alone had a mean haemoglobin level of 9.8 g/dL. This was only 6.4 g/dL in women who had peripheral parasitaemia associated with placental malaria, significantly lower than that observed among the aparasitaemic group (11.2 g/dL) ($F = 63.3$; $P > 0.05$). All other blood parameters followed the same pattern. The mean red blood cell count for women with coincident infection ($2.9 \times 10^6/\mu L$) was much lower than in those who had peripheral parasitaemia alone or were aparasitaemic.

Discussion

Of the 276 women investigated in our study, 17 (6.2%) had the malaria parasite (*P. falciparum*) in their peripheral blood. This low prevalence could be an outcome of many interacting factors. Anti-malarial drugs, mostly chloroquine, had been given to 26.4% of the women during the current pregnancy. Also, 34.4% had not visited antenatal care clinics during their pregnancy. Thus they missed out on antenatal care, which has a beneficial impact on mothers

Table 5 **Association between maternal anaemia (haemoglobin < 10 g/dL) and gestational age at delivery and birth weight**

Variable	Anaemic (*n* = 128)				Non-anaemic (*n* = 148)				Total
	Parasitaemia (*n* = 15)		Aparasitaemia (*n* = 113)		Parasitaemia (*n* = 2)		Aparasitaemia (*n* = 146)		
	No.	%	No.	%	No.	%	No.	%	
Gestational age[b]									
Full term	9	3.6	94	37.8	2	0.8	144	57.8	249
Preterm	6)	22.2	19	70.4	0	0.0	2	7.4	27
OR	3.30		1[a]		18.00		1[a]		
95% CI	0.85–11.74				0.43–308.37				
Birth weight of newborn									
NBW	6	3.1	76	38.8	1	0.5	113	57.6	196
LBW	9	11.2	37	46.3	1	1.2	33	41.3	80
OR	3.08		1[a]		3.42		1[a]		
95% CI	0.89–11.26				0.04–271.11				

[a]Reference group.
[b]Preterm, < 37 weeks.
NBW = normal birth weight, ≥ 2500 g; LBW = low birth weight, < 2500 g.
OR = odds ratio; CI = confidence interval.

and their babies, either through the diagnosis and treatment of malaria infection and other complications of pregnancy or by reducing the modifiable risk factors associated with pregnancy. The low prevalence could also be related to the fact that our

Table 6 **Effect of malaria infection (*Plasmodium falciparum*) on blood parameters and indices**

Blood parameters	Malaria cases			*F*-value	LSD
	Peripheral parasitaemia (*n* = 6) Mean (SD)	Peripheral parasitaemia & placental malaria (*n* = 11) Mean (SD)	Aparasitaemia (*n* = 259) Mean (SD)		
Haemoglobin (g/dL)	9.8 (1.6)	6.4 (2.3)	11.2 (1.36)	63.3	3.4
Packed cell volume (%)	29.7 (4.0)	21.0 (4.6)	35.1 (2.11)	211.8	8.7
Red blood cell count ($\times 10^6$/μL)	4.0 (0.79)	2.9 (0.89)	4.0 (0.38)	36.8	1.1
Meancorpuscular volume (fL)	67.1 (11.5)	48.9 (14.3)	98.7 (7.9)	227.2	18.2
Mean corpuscular haemoglobin (pg)	22.3 (7.0)	17.3 (6.3)	36.2 (6.3)	60.0	13.9
Mean corpuscular haemoglobin concentration (g/dL)	29.7 (4.2)	25 (4.8)	34 (5.6)	15.4	4.7

LSD = least significant difference value.
SD = standard deviation.

study was conducted on a select group of women with uncomplicated vaginal deliveries. Finally, the sample size was relatively small (276 participants) as most Yemeni women prefer to have their babies either at home, supervised by trained midwives, or in private hospitals [*12*].

Our findings indicate that primigravidae, maternal age less than 20 years and rural residence are potential risk factors predisposing to malaria infection. The risk of malaria infection decreased as gravidity increased, prevalence was highest in primigravidae, who had an 8.3 times greater risk of infection than secundigravidae, confirming the high vulnerability of this group in malaria endemic regions [*13*]. Maternal malaria has the most evident impact during first pregnancies, becoming less severe during second and subsequent ones [*14*]. The increased susceptibility of primigravidae to malaria has been attributed to immunosuppression [*15*] or sequestration of infected red blood cells in the placenta through binding to chondroitin sulfate A in the placenta syncytiotrophoblast [*16*]. Conversely, several mechanisms underlying increased resistance of multigravid women to the severe effects of malaria have been proposed. These include the presence of agglutinating antibodies against a wide range of placental parasite isolates in sera of multigravid women [*17*] and the existence of a sub-population of *P. falciparum* parasites that specifically bind placental chondroitin sulfate A with development of antibodies against the chondroitin sulfate A-binding parasites in multigravid women [*18*].

Maternal age was the second risk factor examined in our study. Pregnant women under 20 years of age had a 4.93 times higher estimated risk of malaria infection than those in the age group 20–34 years. This finding confirms the observation of the World Health Organization which reported that those who get pregnant before the age of 18 years may have a 5-fold higher risk of pregnancy-related complications than women who get pregnant when aged 20–25 years [*19*].

We also investigated the effect of residential area. Rural areas have environmental conditions more favourable to transmission of the disease than urban areas. We found that malaria was more prevalent among pregnant women from rural areas and they were at a 5.18 times greater risk than those from urban areas.

Cord parasitaemia was not recorded in our study, in agreement with the view that congenital malaria is rare, even in malaria-endemic areas such as sub-Saharan Africa, where prevalence varies from 0% to 23% [*20*].

Coincident infection of peripheral parasitaemia and placenta malaria occurred in 64.7% of malaria-infected women in the study area, compared to 75.5% recorded in Tanzania [*21*]. On the other hand, a lower percentage (18.5%) was reported in Sierra Leone [*4*]. Moreover, the prevalence of coincident infection from rural areas was greater than that reported from the urban area. Prevalence of primigravidae in women from rural areas was greater than in those from urban areas. This could indicate hyperendemicity in the rural areas and mesoendemicity in the urban areas.

Our study shows a strong association between coincident infection and both preterm delivery and LBW babies. The risk for preterm delivery was 9.44 times greater and for having a LBW baby risk was 12.2 times greater. This is in agreement with the observation of Morgan who reported that placental infection affects fetoplacental function, which in turn, affects fetal growth and/or prematurity [*4*].

The impact of placental malaria-related changes on gestational age and birth weight has also been studied by Menendez et al. [*21*] in Tanzania and Sullivan et al. [*22*] in Malawi. They reported that birth weight may be affected via placental insufficiency, which leads to intrauterine growth retardation. They observed that massive mononuclear intervillous inflammatory infiltration was associated with increased risk of LBW. Parasitized maternal red blood cells and perivillous fibrin deposition were independently associated with increased risk of premature delivery.

Anaemia in pregnancy has become a common clinical problem in many developing countries [*23*]. It has been reported to contribute significantly to maternal mortality [*24*] and to both maternal and fetal morbidity [*25*]. In our study, coincident infection had a significantly higher risk of inducing maternal anaemia by reducing the haemoglobin concentration. Also, the parasitaemic, anaemic women had a 3.3 times higher risk of preterm delivery compared to those who were anaemic but aparasitaemic. Similarly, the women who were parasitaemic but non-anaemic had an 11.6 times higher risk of preterm delivery than those belonging to aparasitaemic non-anaemia group. The same pattern is true with LBW babies. The women who were parasitaemic and anaemic and those who were parasitaemic but non-anaemic had a 3.1 times higher risk of having LBW babies than those who were aparasitaemic anaemic and a 3.4 times higher risk than those who were aparasitaemic but non-anaemic. Thus, we can conclude that in malaria-endemic areas such as Al Hodeidah governorate, malaria infection is a more important risk factor for both preterm delivery and LBW babies than anaemia, and indirectly influences neonatal mortality. Our findings support the observation of Brabin and Piper, who concluded that malaria infection was a more important risk factor for LBW than maternal anaemia [*26*].

The causes of maternal malarial parasitic anaemia are multifactorial and cannot be explained simply by the direct destruction of parasitized red blood cells at the time of release of merozoites [*27*], but include inhibition of erythropoiesis [*28*], loss of infected red blood cells in the spleen [*29*] and elevated levels of tumour necrosis factor α in the placenta [*18*]. In addition persistent low-grade parasitaemia leads to persistent haemolysis, reticulocytosis and megaloblastosis because of folic acid deficiency [*30*].

We found that maternal anaemia in general was extremely common; 46.4% of the participants were anaemic. In 11.7% of these, the anaemia was associated with malaria parasitaemia, indicating that *P. falciparum* infection is an important cause of anaemia in pregnant women.

The findings also revealed that microcytic hypochromic anaemia was the predominant type of anaemia among pregnant women infected with malaria. The severity of anaemia increased when peripheral parasitaemia was associated with placental malaria, indicating that anaemia during pregnancy is most often believed to result from nutritional deficiencies, especially iron deficiency [*31*]. However, folate deficiency, vitamin A deficiency and vitamin B_{12} deficiency have all been found to contribute to anaemia [*32–34*]. Thus, the etiological factors responsible for anaemia in pregnancy are multiple and their relative contributions can be expected to vary by geographical area. Knowledge of the relative importance of the different causes should form the basis for intervention strategies to control anaemia in pregnancy [*35*].

A very low red blood cell count was observed in pregnant women with coinci-

dent infection. This may be an outcome of haemolytic anaemia associated with malaria infection [*36*]. Immunological factors play an important role in the etiology of haemolytic anaemia associated with malaria and the reduction in the life span of the red blood cells persists for several weeks after acute infection [*37*].

In conclusion, this work represents a preliminary study of malaria during pregnancy in Yemen. The results confirm that *P. falciparum* infection in pregnancy is significantly associated with maternal anaemia of the microcytic hypochromic type, besides the haemolytic anaemia which accompanied malaria infection. Young primigravidae are the most vulnerable group affected and they have more preterm deliveries and LBW babies.

Effective measures aimed at preventing malaria in primigravidae would scientifically reduce anaemia attributable to *P. falciparum* infection and the deleterious effects on both mother and baby. Motivating pregnant women of all parities to utilize antenatal care services is a must, especially since most of the pregnant women in this study were illiterate (71.0%), and the vast majority were housewives (85.5%). In addition, about 80.8% of them were married before they were 20. About one third of the women in our study did not visit the antenatal care services at all.

It has been shown that intermittent treatment in the second and third trimesters of pregnancy with sulphadoxine–pyrimethamine can reduce severe maternal anaemia in primigravidae [*38*] and significantly improve birth weight in primigravidae and secundigravidae [*39*]. The introduction of a policy incorporating this strategy would be appropriate for rural Al Hodeidah governorate, where malaria is hyperendemic.

References

1. ***National malaria control programme, annual report for the year 2000***. Sana'a, Yemen, Ministry of Health, 2000.
2. ***The work of WHO in the Eastern Mediterranean Region, annual report of the Regional Director, 2000***. Cairo, World Health Organization Regional Office for the Eastern Mediterranean, 2001, 147–54.
3. Watkinson M, Rushton DI, Lunn PG. Placental malaria and foetoplacental function: low plasma oestradiols associated with malarial pigmentation of the placenta. ***Transactions of the Royal Society of Tropical Medicine and Hygiene***, 1985, 79(4):448–50.
4. Morgan HG. Placental malaria and low birthweight neonates in urban Sierra Leone. ***Annals of tropical medicine and parasitology***, 1994, 88:575–80.
5. Brabin BJ. ***The risks and severity of malaria in pregnant women***. Geneva, World Health Organization, 1991 (Applied field research in malaria reports No. 1).
6. ***Statistical year book–2000***. Sana'a, Yemen, Central Statistical Organization, Ministry of Planning and Development, 2001:5–13.
7. ***Yemen demographic and maternal and child health survey 1991/1992***. Sana'a, Yemen, Central Statistical Organization, & Cairo, Egypt, Pan Arab Project for Child Development & Calverton, Maryland, USA, Macro International Inc., 1994.
8. Regional demographic and health indicators. ***Eastern Mediterranean health journal***, 2000, 6(4):843–7.

9. ***Basic malaria microscopy, Part 1. Learner's guide***. Geneva, World Health Organization, 1991.

10. Dacie JV, Lewis SM. ***Practical haematology***, 7th ed. Edinburgh, Churchill Livingstone, 1991:76–80.

11. Ndyomugyenyi R, Magnussen P. Anaemia in pregnancy: ***Plasmodium falciparum*** infection is an important cause in primigravidae in Hoima district, Western Uganda. ***Annals of tropical medicine and parasitology***, 1999, 93(5): 457–65.

12. Ba-amer A, Ghanim S. Low birth weight: the effect of antenatal care. ***Journal of the Arab Board of Medical Specialization***, 2000, 2(4):21–6.

13. Diagne N et al. Incidence of clinical malaria in pregnant women exposed to intense perennial transmission. ***Transactions of the Royal Society of Tropical Medicine and Hygiene***, 1997, 91(2): 166–70.

14. Steketee RW et al. ***Malaria prevention in pregnancy: The effects of treatment and chemoprophylaxis on placental malaria infection, low birth weight, and fetal, infant, and child survival***. USAID/US Department of Health and Human Services (available from Centers for Disease Control and Prevention, Atlanta, Georgia), 1994.

15. Rasheed FN et al. Suppressed peripheral and placental blood lymphoproliferative response in first pregnancies: relevance to malaria. ***American journal of tropical medicine and hygiene***, 1993, 48(2):154–60.

16. Rogerson SJ, Brown GV. Chondroitin sulphate A as an adherence receptor for ***Plasmodium falciparum***-infected erythrocytes. ***Parasitology today***, 1997, 13(2): 76–9.

17. Beeson JG et al. Plasmodium falciparum isolates from infected pregnant women and children are associated with distinct adhesive and antigenic properties. ***Journal of infectious diseases***, 1999, 180: 464–72.

18. Fried M et al. Maternal antibodies block malaria. ***Nature***, 1998, 395(6705):851–52.

19. ***Safe motherhood newsletter***. Geneva, World Health Organization, 1996 (Issue 22).

20. Fischer PR. Congenital malaria: an African survey. ***Clinical pediatrics***, 1997, 36(7):411–3.

21. Menendez C et al. The impact of placental malaria on gestational age and birth weight, ***Journal of infectious diseases***, 2000, 181(5):1740–5.

22. Sullivan AD al. Malaria infection during pregnancy: intrauterine growth retardation and preterm delivery in Malawi. ***Journal of infectious diseases***, 1999, 179(6):1580–3.

23. ***The prevalence of anaemia in women: a tabulation of available information***, 2nd ed. Geneva, World Health Organization, 1992 (WHO/MCH/MSM/92.2).

24. Harrison KA. Tropical obstetrics and gynaecology. 2. Maternal mortality. ***Transactions of the Royal Society of Tropical Medicine and Hygiene***, 1989, 83(4): 449–53.

25. Klebanoff MA et al. Anemia and spontaneous preterm birth. ***American journal of obstetrics and gynecology***, 1991, 164(1): 59–63.

26. Brabin B, Piper C. Anaemia- and malaria-attributable low birthweight in two populations in Papua New Guinea. ***Annals of human biology***, 1997, 24(6):547–55.

27. Menendez C, Fleming AF, Alonso PL. Malaria-related anaemia. ***Parasitology today***, 2000, 16(11):469–76.

28. Kurtzhals JA et al. Reversible suppression of bone marrow to erythropoietin in Plasmodium falciparum malaria. ***British journal of haematology***, 1997, 97(1): 169–74.

29. Brabin BJ et al. Consequences of maternal anaemia on outcome of pregnancy in a malaria endemic area in Papua New Guinea. ***Annals of tropical medicine and parasitology***, 1990, 84(1):11–24.

30. Fleming AF. The aetiology of severe anaemia in pregnancy in Ndola, Zambia. ***Annals of tropical medicine and parasitology***, 1989, 83(1):37–49.

31. DeMaeyer EM, Adiels-Tegman M. The prevalence of anaemia in the world. ***World health statistics quarterly***, 1985, 38(3):302–16.

32. ***Prevention and management of severe anaemia in pregnancy. Report of a technical working group***. Geneva, World Health Organization, 1993 (WHO/FHE/MSM/93.5).

33. Suharno D et al. Supplementation with vitamin A and iron for nutritional anaemia in pregnant women in West Java, Indonesia. ***Lancet***, 1993, 342 (8883):1325–8.

34. Savage D et al. Vitamin B12 deficiency is the primary cause of megaloblastic anaemia in Zimbabwe. ***British journal of haematology***, 1994, 86(4):844–50.

35. ***Report of the African regional consultation on control of anaemia in pregnancy***. Brazzaville, Congo, World Health Organization Regional Office for Africa, 1989 (AFR/NUT/104).

36. Gilles HM et al. Malaria, anaemia and pregnancy. ***Annals of tropical medicine and parasitology***, 1969, 63(2):245–63.

37. Woodruff AW, Ansdell VE, Pettitt LE. Cause of anaemia in malaria. ***Lancet***, 1979, 1(8125):1055–7.

38. Shulman CE et al. Intermittent sulphadoxine-pyrimethamine to prevent severe anaemia secondary to malaria in pregnancy: a randomized placebo-controlled trial. ***Lancet***, 1999, 353(9153):632–6.

39. Parise ME et al. Efficacy of sulphadoxine-pyrimethamine for prevention of placental malaria in an area of Kenya with a high prevalence of malaria and human immunodeficiency virus infection. ***Journal of tropical medicine and hygiene***, 59(5):813–22.