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Malaria and anaemia among pregnant women at first antenatal clinic visit in Kisumu, western Kenya

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Summary

OBJECTIVE To determine the prevalence of malaria and anaemia among urban and peri-urban women attending their first antenatal clinic (ANC) in an area of perennial malaria transmission.
METHODS Between November 2003 and May 2004 we screened first ANC attenders for malaria and anaemia in a large urban hospital in Kisumu (western Kenya) and interviewed them to obtain demographic and medical information.
RESULTS Among the 685 study participants, prevalence of malaria parasitaemia was 18.0%, prevalence of any anaemia (haemoglobin < 11 g/dl) was 69.1% and prevalence of moderate anaemia was (haemoglobin < 8 g/dl) 11.8%. Sixteen women were hospitalized during pregnancy, eight because of malaria. In multivariate analysis, young age, living in a house with mud walls, a visit to rural area, peri-urban residence, second trimester of pregnancy and Luo ethnicity were significant risk factors for malaria parasitaemia. Malaria was an important risk factor for any and moderate anaemia; use of an insecticide-treated net (ITN) was a protective factor for any anaemia. Married women with a higher level of education, better-quality housing and full-time employment were more likely to use an ITN.
CONCLUSION Malaria and anaemia are established problems by the time of the first ANC visit. Mechanisms to deliver ITNs to women of child-bearing age before they become pregnant need to be explored. Early ANC visits are warranted in order for women to benefit from policies aimed at reducing the burden of malaria and anaemia.

keywords malaria, anaemia, pregnancy, antenatal, insecticide-treated nets, Kenya

Introduction

Approximately 30 million pregnant African women are exposed to the risk of malaria infection every year (World Health Organization/UNICEF 2003). In areas of intense transmission, *Plasmodium falciparum* infection during pregnancy is usually asymptomatic and therefore remains undetected and untreated, despite the presence of parasites in the placenta. The main adverse manifestations of malaria in pregnancy are maternal anaemia and low birth weight babies (Brabin 1983; Menendez 1995; Steketee *et al.* 2001). In Kenya, it is estimated that 6000 primigravidae develop severe malaria-induced anaemia each year and approximately 4000 infants have low-birth-weight (Snow *et al.* 1998). Low birth weight is an important risk factor for neonatal and infant mortality (McCormick 1985); 8–19% of low birth weight and 3–8% of infant mortality are attributable to malaria (Guyatt & Snow 2001a, 2004; Steketee *et al.* 2001).

Anaemia in pregnancy is estimated to affect approximately 50% of pregnant women in malaria-endemic countries of Africa (World Health Organization 1992; WHO/UNICEF/UNU 2001). Anaemia is usually multifactorial in origin and although malaria is an important contributor, nutritional deficiencies (iron and folate), other infectious diseases (hookworm, schistosomiasis and HIV) and genetic red blood cell disorders (sickle cell and thalassaemias) are other important contributing factors (van den Broek 1998; Shankar 2000). Malaria may cause anaemia through a number of different mechanisms including excess removal of non-parasitized erythrocytes, immune destruction of parasitized red cells, and impaired erythropoiesis as a result of bone marrow dysfunction (Ekvall 2003). Malaria accounts for an estimated 3–15%

of anaemia and 25% of severe anaemia in pregnant women in endemic countries (Guyatt & Snow 2001b; Steketee *et al.* 2001).

Interventions recommended to prevent malaria and associated anaemia during pregnancy include intermittent preventive treatment (IPTp) with sulphadoxine-pyrimethamine (SP) (Parise *et al.* 1998; Shulman *et al.* 1999), and use of insecticide-treated nets (ITNs) (Shulman *et al.* 1998; ter Kuile *et al.* 2003; WHO/AFRO 2004). When used by women during their first four pregnancies, ITNs reduced maternal malaria-related anaemia (haemoglobin < 8 g/dl with parasitaemia) by 47% and parasitaemia by 38% (ter Kuile *et al.* 2003). ITNs significantly reduce placental malaria in all pregnancies and reduce the incidence of low birth weight and stillbirths/abortions in the first to fourth pregnancy (Gamble *et al.* 2006). Similarly, IPTp with SP significantly reduces the percentage of low birth weight babies and prevents severe anaemia in pregnant women (Shulman *et al.* 1999).

Given the public health importance of malaria and anaemia in pregnancy and the high antenatal clinic (ANC) attendance in sub-Saharan Africa, understanding risk factors for malaria and anaemia in pregnancy could lead to better planning of ANC interventions. We aimed to determine the extent of malaria and anaemia among urban and peri-urban ANC attenders in an area of perennial malaria transmission and to assess associated factors.

Materials and methods

Study site

The study was conducted at the Nyanza Provincial General Hospital, a large government referral hospital in Kisumu district (population 500 000 inhabitants) on the northern shores of Lake Victoria in western Kenya. It provides health care to local low-income population. About 90 women attend the prenatal clinic service daily, of whom 33% arrive for their first antenatal visit. The hospital offers routine and specialized health services, including maternal and child health clinics, prevention of mother-to-child transmission of human immunodeficiency virus (HIV) and voluntary counselling and testing for HIV. Since 1999, IPTp with SP was routinely administered as part of ANC care for malaria prevention. Residents are mainly of the Luo ethnic group who earn their living through subsistence farming, fishing and small businesses (Ouma 2001; Phillips-Howard *et al.* 2003). Long rains fall from March through May and short rains from October through November (Bloland *et al.* 1999). Malaria transmission is perennial and holo-endemic.

In Kenya the widespread resistance to SP has necessitated a shift to artemisinin-based combination therapy (ACT), specifically artemether-lumefantrine, as the first line treatment for uncomplicated malaria in non-pregnant populations and to oral quinine for uncomplicated malaria in all trimesters of pregnancy (Ministry of Health Kenya 2006). However, SP given as IPTp remains the recommended drug for prevention of malaria during pregnancy.

Participants

The study population consisted of first ANC attenders who were screened for participation in a randomized trial to assess the effect of folic acid supplementation on the efficacy of SP for prevention and treatment of malaria during pregnancy (Ouma *et al.* 2006). Criteria for screening included gestational age >16 and <35 weeks, age between 15 and 45 years, and residence within the Kisumu municipality. After obtaining informed consent, trained study staff collected the baseline information on demographic characteristics, obstetric and medical history, and prior antimalarial drug use. Height, weight and axillary temperature were measured independently by two study assistants and the average of the two measurements was used in analyses.

Laboratory methods

Blood was obtained by venipuncture; blood films were stained in 10% Giemsa for 15 min and examined under oil immersion for malaria parasites. A thick film was considered as negative if 100 microscopic fields showed no parasites. For quality control, 10% of the negative samples and 20% of the positive samples were re-examined by different microscopists during the study. The haemoglobin level of pregnant women was measured to the nearest 0.1 g/dl using Haemocue (Hemocue AB, Angelholm, Sweden).

Definitions

Malaria was defined as the presence in the peripheral blood of asexual blood stage of *Plasmodium*, irrespective of species or symptoms. *Any anaemia* was defined as a haemoglobin <11 g/dl and *moderate anaemia* was defined as a haemoglobin <8 g/dl. The *body mass index* (BMI) was calculated as weight (kg) divided by the squared height (meters); a *low BMI* was defined as a BMI < 22.0 kg/m^2, the 25th percentile among participants. *A documented fever* was defined as an axillary temperature ≥37.5 °C. A *high socio-economic status* (SES) was defined as the presence of electrical supply to the residence. An *ITN* was defined as a bed net that was treated with an insecticide in the last 6 months. A *young age* was defined as age <20 years. *Urban areas* were areas located in or immediately around the centre of Kisumu town; peri-urban areas were located at the outskirts of Kisumu that border the rural areas (van Eijk *et al.* 2002).

Data management and statistical analysis

Differences in means were compared using the Student's *t*-test or a non-parametric test, if appropriate. Differences in proportions were analyzed using the Chi-square or Fisher's exact test, if appropriate. The following factors were evaluated as potential risk factors for malaria parasitaemia, anaemia and moderate anaemia: age, gravidity, marital status, education level, maternal occupation, ethnicity (Luo *vs.* non-Luo), location of residence (urban *vs.* periurban), housing characteristics (type of roof, windows, walls, presence of electricity), number of persons in the residence, a stay for at least one night in a malarious rural area in the preceding month, season at the time of visit (rainy *vs.* dry), source of water for the household, antimalarial use in the preceding month, and possession of an ITN. For anaemia and moderate anaemia, malaria parasitaemia, and history of fever in the preceding week were evaluated as well. Prevalence ratios were computed with 95% confidence interval (CI) to measure the strengths of the associations. We then modeled in multivariate analysis using a backward variable selection procedure, whereby factors with *P*-value >0.08 were removed from the model (Spiegelman & Hertzmark 2005). Factors associated with the use of an ITN were evaluated in the same way. All statistical analyses were performed using the statistical program SAS (SAS system for windows version 8; SAS Institute, Cary, NC, USA). For all statistical tests, a two-sided *P* value < 0.05 was considered significant.

Ethical review and informed consent

The study protocol was reviewed and approved by the institutional review boards of the Kenya Medical Research Institute (Nairobi, Kenya) and the Centers for Disease Control and Prevention (Atlanta, GA, USA). All study participants provided informed consent.

Results

Characteristics of the study population

Between November 2003 and May 2004 we screened 1864 women; 852 were eligible for the study and 685 agreed to participate (80.4%). The proportion of women <20 years and of primigravidae was similar among non-participants and participants (age < 20 years: 40.2% *vs.* 40.5%; primigravidae: 46.0% *vs.* 44.9%, respectively, *P* > 0.05).

The median age of the 685 participants was 20 years (range 15–42), the median gestational age was 27 weeks (range 17–34). Eleven women (1.6%) had never attended school, 119 (17.4%) had completed secondary school. The median BMI was 23.5 kg/m^2 (range 16.8–45.1). Eighteen per cent had spent a night in a rural area in the month before the interview (Table 1). Although 42% had fever in the preceding week, only three women (0.4%) had fever at the time of their interview. Antimalarial treatment during pregnancy was only used by 4.5%. Sixteen women (2.3%) reported a hospital admission during the current pregnancy; malaria was the most common reason and mentioned by eight women. Two women reported using haematinics at the time of interview.

Factors associated with malaria infection

Malaria parasitaemia was detected in 123 (18%) of 685 blood smears; 120 were *P. falciparum* infections, two were mixed infections of *P. falciparum* and *P. malariae* and one was a *P. malariae* infection. Malaria prevalence decreased with increasing gravidity (Figure 1). As expected, parasitemia and a history of fever in the last week were significantly associated [relative risk (RR) 1.44, 95% CI 1.05–1.98].

Use of antimalarials in the preceding month, maternal occupation (housewife *vs.* other employment), type of windows of the house and season at the time of interview were not associated with malaria parasitaemia (data not shown). Most factors associated with malaria in univariate analysis (Table 1), remained significant in multivariate analysis (Table 2), except for marital status and use of an ITN. The association between ITN use and parasitaemia did not reach statistical significance (*P* = 0.08).

Factors associated with anaemia and haemoglobin level

The prevalence of any anaemia was 69.1%, and that of moderate 11.8%; the mean haemoglobin was 10.1 g/dl (standard deviation 1.6 g/dl). Predictors of any anaemia in univariate analysis were Luo ethnicity (RR 1.22, 95% CI 1.06–1.40), low level of education (RR 1.18, 95% CI 1.07–1.31), house with mud walls (RR 1.12, 95% CI 1.01–1.25), low BMI (RR 1.10, 95% CI 1.00–1.23), and malaria parasitaemia (RR 1.37, 95% CI 1.25–1.49). In multivariate analysis, only Luo ethnicity and malaria parasitaemia remained significant predictors of any anaemia (Table 3); spending a night in a rural area and ITN use were protective of any anaemia.

Table 1 Prevalence of malaria parasitaemia in pregnant women at first antenatal visit by selected characteristics, Kisumu, 2003–2004

	n (%)*	Prevalence, *n* (%)	Unadjusted prevalence ratio(95% CI) †	*P*-value
Overall	685	123 (18.0)		
Maternal age				
<20 years	277 (40.5)	63 (22.7)	**1.54** (1.12–2.12)	0.008
≥20 years	407 (59.5)	60 (14.7)		
Gravidity				
Primigravidae	307 (44.9)	66 (21.5)	**1.42** (1.03–1.96)	0.03
Multigravidae	377 (55.1)	57 (15.1)		
Ethnicity				
Luo	518 (75.6)	107 (20.7)	**2.16** (1.31–3.54)	0.002
Other ethnicity	167 (24.4)	16 (9.6)		
Education <8 years schooling				
Yes	170 (24.9)	36 (21.2)	1.25 (0.88–1.77)	0.2
No	514 (75.2)	87 (16.9)		
Single				
Yes	164 (23.9)	40 (24.4)	**1.53** (1.10–2.14)	0.01
No	521 (76.1)	83 (15.9)		
Electricity in residence				
Yes	158 (23.1)	22 (13.9)	0.73 (0.47–1.11)	0.1
No	527 (76.9)	101 (19.2)		
Main source drinking water				
Tap water	596 (87.0)	101 (17.0)	0.69 (0.46–1.03)	0.07
Other source (surface water/well)	89 (13.0)	22 (24.7)		
Residence with mud walls				
Yes (plain or mixed with cement)	383 (56.7)	84 (21.9)	**1.78** (1.24–2.55)	0.002
No	292 (43.3)	36 (12.3)		
Number of persons in household				
<7	565 (82.5)	95 (16.8)	0.72 (0.50–1.05)	0.08
≥7	120 (17.5)	28 (23.3)		
Location of residence				
Peri-urban	149 (21.8)	39 (26.2)	**1.67** (1.20–2.33)	0.003
Urban	536 (78.3)	84 (15.7)		
Spent night in rural malarious area‡				
Yes	123 (18.0)	34 (27.6)	**1.75** (1.24–2.46)	0.002
No	562 (82.0)	89 (15.8)		
Trimester of visit				
Second-trimester	446 (65.1)	92 (20.6)	**1.59** (1.09–2.32)	0.02
Third-trimester	239 (34.9)	31 (13.0)	Reference	
A low BMI (<22.0 kg/m^2)				
Yes	171 (25.0)	28 (16.4)	0.89 (0.60–1.30)	0.5
No	514 (75.0)	95 (18.5)	Reference	
Bed net use during pregnancy				
Regularly treated bed net	221 (32.4)	29 (13.1)	**0.62** (0.42–0.93)	0.02
Not regularly treated bed net	125 (18.3)	23 (18.4)	0.87 (0.57–1.33)	0.5
No bed net use	337 (49.3)	71 (21.1)	Reference	

CI, confidence interval.
Significant prevalence ratios are printed in bold.
*Sums may not add up to 685 because of missing values.
†From univariate binomial regression models in which malaria parasitemia is the outcome variable.
‡Within the previous month.

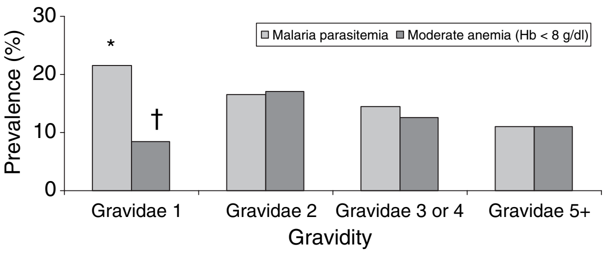

Figure 1 Prevalence of malaria and moderate anaemia among 685 first ANC attenders in Kisumu, Kenya, 2003–2004. *$P < 0.05$ comparing malaria among Gravidae 1 to Gravidae 3 or 4 and Gravidae 5+. †$P < 0.05$ comparing moderate anaemia among Gravidae 1 to Gravidae 2.

Table 2 Factors associated with malaria parasitaemia at the first antenatal visit, multivariate analysis, Kisumu 2003–2004

	Adjusted prevalence ratios (95% CI)*	*P*-value
Age < 20 years	**1.45** (1.08–1.95)	0.01
Luo ethnicity	**1.95** (1.17–3.24)	0.01
Residence with mud walls	**1.55** (1.08–2.23)	0.02
Peri-urban residence	**1.58** (1.16–2.17)	0.004
Spent night in rural malarious area†	**1.86** (1.36–2.53)	<0.0001
Second-trimester	**1.56** (1.08–2.24)	0.02
Bed net use during pregnancy		
Regularly treated bed net	0.70 (0.47–1.04)	0.08
Not regularly treated bed net	0.91 (0.60–1.40)	0.7
No bed net use	Reference	

CI, confidence interval.
Significant prevalence ratios are printed in bold.
*Because of co-linearity, gravidity and age were not introduced simultaneously in the model. In a model with gravidity, the adjusted prevalence ratio for primigravidae was 1.43, 95% CI 1.04–1.95, with not much change among the other factors.
†Within the previous month.

The prevalence of moderate anaemia was significantly lower in primigravidae (Figure 1). Only primigravid status and malaria parasitaemia remained associated with moderate anaemia in the multivariate model (Table 3). Gravidity and a low BMI interacted (*P*-value interaction term 0.05). Compared to multigravidae with a normal BMI, primigravidae with a low BMI had an adjusted prevalence ratio for moderate anaemia of 0.48 (95% CI 0.20–1.20); multigravidae with a low BMI had a prevalence ratio of 1.87 (95% CI 1.14–3.07) and primigravidae with a normal BMI had a prevalence ratio of 0.74 (95% CI 0.45–1.22).

Factors significantly associated with haemoglobin level in multivariate linear regression analysis included Luo ethnicity, a low BMI, second trimester of pregnancy, ITN use, and fever in the previous week, and malaria parasitaemia (Table 3).

Factors associated with the use of an insecticide-treated net

An interaction was noted between the presence of electricity in the home and house walls made of mud, thus they were combined in one variable. Fifty-three per cent of women living in a house without mud walls and with electricity reported the use of an ITN, whereas this was much less common among the other groups (23.8% among women with electricity in their house and mud walls, 26.7% among women with no electricity and mud walls, and 33.1% among women with no electricity and no mud walls). In multivariate analysis, important independent predictors of ITN use were schooling of <8 years (RR 0.66, 95% CI 0.47–0.92), being single (RR 0.67, 95% CI 0.47–0.95), listening to the radio at least once a week (RR 1.21, 95% CI 0.98–1.49), full-time employment (RR 1.29, 95% CI 1.04–1.60), and the presence of electricity and no mud walls in the house (RR 1.50, 95% CI 1.15–1.95).

Discussion

We report a high prevalence of anaemia, almost 70% among pregnant women in this urban/peri-urban area of Kisumu, with malaria as one of the most important determinants of anaemia and haemoglobin level. Important risk factors for malaria were factors related to increased exposure, such as a recent stay in areas surrounding Kisumu, or peri-urban residence where malaria transmission is higher. The use of an ITN was associated with a reduced risk of malaria parasitaemia and anaemia and an increase in haemoglobin level.

The increased risk of malaria among primigravidae has been well described (Brabin 1983) and is again seen in this study population. However, primigravidae were not the group with greatest risk of moderate anaemia in this study, indicating that other causes of anaemia might also be important, and were more common among the higher gravidity groups.

Luo ethnicity was associated with the highest risk ratio for malaria parasitaemia independently of visits to rural areas, and was associated with an increased risk of anaemia as well, confirming previous studies in the same population (van Eijk *et al.* 2001, 2002). Differences in susceptibility to malaria by ethnicity have been reported before from Mali (Dolo *et al.* 2005). In the studies in Kisumu, the risk of malaria infection was independent of HIV, or SES, or location of residence, and the risk on anaemia was independent of HIV-infection, malaria and nutritional status (van Eijk *et al.* 2001, 2002). Higher rates

Table 3 Factors associated with any and moderate anaemia and maternal haemoglobin level at the first antenatal visit, multivariate analysis, Kisumu 2003–2004

	Adjusted prevalence ratios Hb < 11 g/dl* (95% CI)	*P*-value	Adjusted prevalence ratios Hb < 8 g/dl* (95% CI)	*P*-value	Adjusted mean haemoglobin differences, g/dl, using linear regression* (95% CI)	*P*-value
Primigravidae			**0.56** (0.36–0.86)	0.008		
Luo ethnicity	**1.16** (1.02–1.31)	0.03			**−0.29** (−0.56 to −0.03)	0.03
Spent night rural malarious area	**0.87** (0.78–0.97)	0.01				
Low BMI					**−0.28** (−0.54 to −0.02)	0.04
Second trimester of pregnancy					**0.32** (0.08 to 0.55)	0.009
Bed net use during pregnancy						
Regularly treated bed net	**0.87** (0.78–0.96)	0.008			0.24 (−0.02 to 0.49)	0.07
Not regularly treated bed net	0.89 (0.78–1.01)	0.08			0.17 (−0.14 to 0.47)	0.3
No bed net use	Reference				Reference	
Fever in the previous week					**−0.25** (−0.48 to −0.02)	0.04
Malaria parasitaemia	**1.34** (1.24–1.45)	<0.0001	**2.02** (1.31–3.11)	0.002	**−0.95** (−1.25 to −0.66)	<0.0001

Hb, haemoglobin; CI, confidence interval; BMI, body mass index.
Significant prevalence ratios or mean differences are printed in bold.
*Variables were adjusted for other printed factors in column.

of glucose-6-phosphate dehydrogenase deficiency (G6PD) and sickle cell trait among persons of Luo ethnicity or living in the lowlands of western Kenya have been reported (Aluoch 1997; Moormann *et al.* 2003), and alpha-thalassaemia is likely to be present as well (Ojwang *et al.* 1987). In Ghana, sickle cell trait had no effect on asymptomatic parasitaemia or haemoglobin, but it was associated with higher parasite densities (Mockenhaupt *et al.* 2000). The effect of G6PD deficiency on malaria is not clear; alpha-thalassaemia seems not to affect asymptomatic parasitemia but may affect anaemia (Mockenhaupt *et al.* 2000; Wambua *et al.* 2006). However, there may be other unknown genetic or environmental factors or combinations of factors related to our observations.

The association between housing and malaria has been described previously in Africa and elsewhere (Banguero 1984; Koram *et al.* 1995; Ghebreyesus *et al.* 2000). In Matola, a peri-urban area of Maputo, Mozambique, houses with reed roofs and clay walls were independently associated with significantly higher risks of clinical episodes of malaria (Ricardo 1999). In Eritrea, walls made from mud increased an individual's risk for malaria parasitemia compared to individuals living in houses with walls made of other construction materials (Sintasath *et al.* 2005). A recent study in this area also revealed an association between mud walls and malaria infection (Ong'echa *et al.* 2006). These types of housing construction provide microenvironments for mosquitoes and may extend their chance of survival and feeding opportunities (Schofield & White 1984). Our study adds evidence to the body of knowledge of type of housing construction and association with *P. falciparum* infection. Areas where mud-walled houses are common may be priority foci for malaria control efforts. However, houses with mud walls could have been a marker of SES as well.

Although still perennial, malaria transmission in Kisumu is lower than in the more rural surroundings, which is reflected in the levels of parasitemia among pregnant women living in Kisumu. In a survey conducted in 2005 in the rural area of Gem, 70 km west of Kisumu, we noted 52% parasitaemia in primigravidae, and 24.7% in gravidae five or more (van Eijk, unpublished data). Prevalence of malaria was higher among women who had spent a night in a rural area. Interestingly, the higher risk among these women was not associated with an increased risk of anaemia. These findings are consistent with a recent survey in rural western Kenya where anaemia levels among pregnant women were lower overall than what we found in this urban site despite higher levels of parasitaemia (van Eijk, unpublished data). It is possible that better nutrition or increased iron intake in the rural areas may have resulted in reduced anaemia, but we have no information on the diet of participants to evaluate this hypothesis.

Malaria is more common in the first and second trimester (Brabin 1983; Dicko *et al.* 2003), whereas haemoglobin decreases until the end of the third-trimester. Anaemia is a function of plasma volume and red cell mass, both of which increase during pregnancy; but the increase in plasma volume is proportionately greater than the increase in red cell mass (Kelbanoff *et al.* 1989). A previous study in this hospital reported that malaria and HIV infection are important, independent risk factors for third-trimester anaemia (van Eijk *et al.* 2001). The high prevalence of HIV in this area, 18% among women aged 15–49 (Central Bureau of Statistics Kenya and ORC Macro 2004), may have contributed to the high prevalence of anaemia noted in this study, but we did not routinely determine HIV-status.

In sub-Saharan Africa, 68% of the pregnant women make at least one ANC visit (World Health Organization/UNICEF 2003), and the most recent demographic and health survey in Kenya (2003) showed that 88% of women visited the ANC at least once (Central Bureau of Statistics Kenya and ORC Macro 2004). Among these attenders, the median gestational age at first visit was 5.7 months for urban areas and 5.9 months for the rural areas. This high uptake of ANCs by African women, particularly in urban areas, provides an excellent opportunity to implement malaria and anaemia prevention strategies during pregnancy. Policies to address the problem of malaria and anaemia are already in place in malaria endemic countries. They include IPTp with SP, iron, and folate supplementation and provision of ITNs. However, this study demonstrates that many women who start visiting ANC are already parasitaemic and anaemic, and at least some of these strategies may be more effective if implemented earlier. While IPTp is not recommended until after quickening, an earlier start of ITN use and iron and folate supplementation, even before pregnancy, may be beneficial. The timing of the first ANC visit is critical; a previous study in the same hospital showed a median gestational age at first ANC visit of 6.4 months (van Eijk, unpublished data). In a recent cross-sectional survey in rural western Kenya, we found the median gestation age at first ANC visit to be 6 months (Ouma, unpublished data). As the first step, health education strategies should emphasize early clinic attendance as recommended by the WHO (WHO/AFRO 2004).

Maternal malaria and maternal and infant anaemia are important risk factors for infant mortality. In Tanzania, infants born to anaemic mothers had a threefold risk of death compared to those born to non-anaemic mothers (Tanya *et al.* 2004), and placental malaria was an important risk factor for infant anaemia (Cornet *et al.* 1998; Eijk *et al.* 2003). Strategies alleviate maternal malaria and anaemia can be expected to have a positive impact on maternal and child health. ITNs effectively reduce the prevalence of anaemia during pregnancy and women should be encouraged to use them (ter Kuile *et al.* 2003; Gamble *et al.* 2006). Distribution of ITNs through ANC can help, but this does not address the effects of malaria before the first ANC visit (Guyatt *et al.* 2002). More widespread availability and use of ITNs in the general community, along with education on their beneficial effects during pregnancy, can help to achieve coverage among women of reproductive age during conception and the first trimesters, before women start ANC attendance. Offering women of child-bearing age an ITN during child health visits may be another way to reach them before the next pregnancy begins. More creative ways are needed to reach the young, single pregnant women who are at highest risk of malaria. Schools, women groups, youth groups or traditional birth attendants may be additional networks that could be explored.

This study did not assess other known causes of anaemia such as helminthiasis, HIV, and nutritional deficiencies, thus limiting our ability to assess the contribution of other causes of anaemia during pregnancy.

In summary, in our study population, malaria and anaemia were well-established problems at the time of the first ANC visit, malaria being present in almost one out of five women, and anaemia in seven out of 10 women. Malaria was significantly associated with anaemia, whereas ITNs were protective of malaria and anaemia. Pregnant women should not delay their first ANC attendance, and control programmes and collaborating partners should expand their target group for ITNs and increase their availability to all women of child-bearing age.

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