Tropical Medicine and International Health

VOLUME 7 NO 2 PP 149–158 FEBRUARY 2002

Socially marketed insecticide-treated nets improve malaria and anaemia in pregnancy in southern Tanzania

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Summary

OBJECTIVES To study the uptake of socially marketed insecticide-treated nets (ITNs) and their impact on malaria and anaemia in pregnancy; and to report on a discount voucher system which aimed to increase coverage in pregnancy.

METHODS A 12-month cross-sectional study of women in the second or third trimester of pregnancy. ITN use and other factors were assessed by questionnaire and a blood sample taken for malaria parasitaemia and anaemia. 'Non-users' of ITNs included both women not using any net and women using untreated nets.

RESULTS Fifty three per cent of pregnant women used ITNs. Women aged 15–19, primigravidae, unmarried women, and those with no access to cash had the lowest ITN use. Fewer ITN users were positive for malaria than ITN non-users (25 *vs.* 33%: $P = 0.06$), and the protective efficacy (PE) for parasitaemia was 23% (CI 2–41). Multiparous ITN users had a twofold decrease in parasite density compared with multiparous non-ITN users (625parasites/μl *vs.* 1173 parasited/μl: $P = 0.01$). Fewer ITN users were anaemic (Hb < 11 g/dl) than ITN non-users (72 *vs.* 82%: $P = 0.01$). ITNs had a PE of 12% (CI 2–21) against mild anaemia and a PE of 38% (CI 4–60) against severe anaemia (Hb < 8 g/dl). There was a trend in the prevalence of severe, mild and no anaemia, and of high density, low density and no malaria infection by ITN status. Recently treated nets were most effective at preventing malaria and anaemia (prevalence of mild anaemia was 68% compared with 82% for those without nets ($P = 0.002$); prevalence of malaria was 22% compared with 33% for those without nets ($P = 0.02$). Knowledge and reported use of the discount voucher system were low. Further qualitative research is ongoing.

CONCLUSIONS A modest impact of ITNs on pregnancy malaria and anaemia was shown in our high malaria transmission setting. The development of ITN programmes for malaria control should include pregnant women as a specific target group.

keywords pregnancy, malaria, anaemia, insecticide-treated bednets, social-marketing, Tanzania

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Introduction

Plasmodium falciparum malaria is the most important parasitic disease in sub-Saharan Africa, where stable transmission is common. In these areas, women of child-bearing age have a high level of acquired antimalarial immunity but pregnant women represent the most at-risk adult group. This is probably because of hormonal modulation of the immune response during pregnancy, compounded by increased blood volume and sequestration of the parasites in the placenta (Riley *et al.* 1989; Menendez 1995). Compared with their non-pregnant counterparts, the increased susceptibility of pregnant women to *P. falciparum* malaria is manifest in a higher frequency and density of parasitaemia (Brabin 1983; McGregor *et al.* 1983) particularly in primigravidae (Steketee 1989). This increases the risk of abortion, stillbirth, pre-maturity, intrauterine growth retardation, and infants of low birth-weight (Brabin 1991; Menendez 1995; Steketee *et al.* 1996). Malaria is also an under-recognized cause of severe

anaemia in pregnancy where transmission is endemic as it is often asymptomatic (Shulman 1999).

At present, the World Health Organization (WHO) recommends that pregnant women in malaria endemic areas receive a full course of antimalarial treatment at first antenatal attendance followed by regular antimalarial chemoprophylaxis (WHO 1994). The effectiveness of this strategy has been limited by the continuing spread of resistance to antimalarial drugs, poor compliance with routine chemoprophylaxis, and logistical and economic constraints within health services. Many countries have no clear policy for malaria control in pregnancy (Robb 1999).

Insecticide-treated nets (ITNs) have been shown to substantially reduce both mortality and malaria morbidity in children in the African setting (Lengeler 2001). However, trial data of ITN impact on malaria-related morbidity in pregnant women are scarce and contradictory (Dolan *et al.* 1993; D'Alessandro *et al.* 1996; Shulman *et al.* 1998).

Given the impact of ITNs in children there is a major international move to implement ITN programmes on a large scale in Africa. Pregnant women have been specifically designated as a high-risk group and recently African leaders have called for 60% of children and pregnant women to be protected by effective personal protection measures (largely ITNs) in Africa by the year 2005 (Roll Back Malaria 2000). There is currently a need for demonstrating the impact of ITNs under programme situations, as it cannot be assumed that the impact observed under trial conditions can be replicated in the frame of large-scale programmes (Lengeler & Snow 1996).

Here we report a study of the use of socially marketed ITNs amongst pregnant women, and the subsequent impact on malaria and anaemia in pregnancy. We also assessed the use of an ITN discount voucher system as a means of targeting specific groups in a population for the uptake of ITNs.

Materials and methods

Study area

This study was conducted at the Ifakara Health Research and Development Centre (IHRDC), in the Kilombero Valley in southern Tanzania. The area is rural and has intense perennial transmission of malaria (Smith *et al.* 1993). Data from local health services indicate malaria as the principal cause of morbidity, with anaemia amongst the top 10 causes (Tanner *et al.* 1991).

The research was one component of a social-marketing project for insecticide-treated nets (KINET) which is described in detail elsewhere (Armstrong Schellenberg *et al.* 1999). Pre-treated nets and insecticide (branded 'Zuia Mbu' meaning *prevent mosquitoes*) were being promoted, distributed and sold using public and private outlets. There was intense promotion of the home insecticide net treatment kits (subsidized price $0.50 in 1999).

Discount voucher system amongst pregnant women

A voucher system to promote the use of ITNs amongst pregnant women and children under 5 years of age was put in place by the KINET project through MCH clinics (Figure 1). Vouchers reduced the price of the project nets by 17%: equivalent to 3.1 US$ in 1999 *vs.* the full price of 3.8 US$ in 1999. All pregnant women and mothers of children under 5 years of age who presented at MCH clinics within the study area were eligible to receive such a voucher. The aim was to facilitate their access to ITNs and to provide a structured opportunity for the promotion of ITNs to this high-risk group. Protecting pregnant women was also felt to be crucial for protecting infants, who usually sleep with their mothers. Vouchers could be used at any official project net outlet. Net outlet retailers then returned the vouchers to the project for reimbursement and were given a small handling fee.

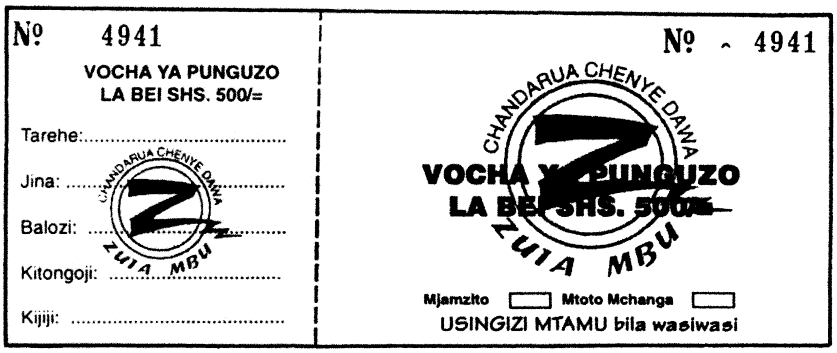

Figure 1 A discount voucher to reduce the price of a socially marketed ITN used during the KINET implementation of ITNs. Name and address of recipient were recorded (left) and whether the recipient was a pregnant woman or a child (right).

A demographic surveillance system (DSS) covering the first 25 villages to be included in the project (approximately 65 000 people living in 11 000 households) was started in September 1996 and is ongoing (Armstrong Schellenberg *et al.* 2001b). Name, sex, date of birth, and relationships within the household were recorded at baseline. Each household is visited every 4 months by an interviewer who updates the census record by asking about in- and out-migrations, pregnancies, births and deaths. Special surveys are added from time to time, for example to record household socio-economic status, and this provided the framework for the present study.

Recruitment and consent

We did a cross-sectional study with rolling recruitment of all pregnant women within six villages close to IHRDC (Figure 2) over a period of 12 months (September 1998 to August 1999). Pregnant women were identified by DSS interviewers at routine 4-monthly visits to each household, when each woman was asked the approximate gestation of pregnancy. All pregnancy reports from the six study villages were eligible for enrolment into the study. Women were often in their third trimester before they reported their pregnancy, so in order to minimize missed pregnancies because of women delivering before being enrolled in the study, priority for recruitment was given to those women in the later stages of pregnancy.

A nurse-midwife travelled daily into the study area spending one day per week at each of the three MCH clinics. On 2 days each week home visits were made to women identified by the DSS as being pregnant but who had not been identified at a clinic. A detailed description of the project was given and written consent obtained before proceeding with the interview. A questionnaire was administered including information about socio-economic status, fertility, use of health facilities, use of nets and knowledge of the social marketing discount voucher system. All field work was conducted in Swahili, which is widely spoken in the study area. Each woman was seen only once.

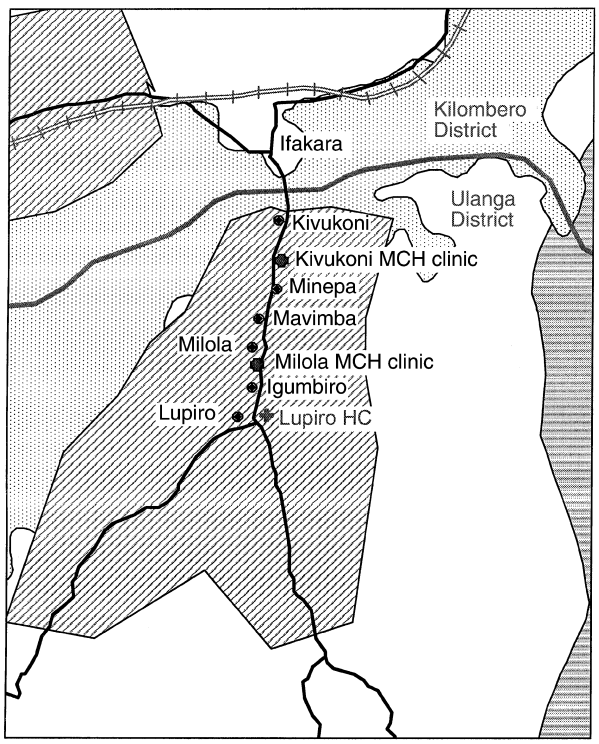

Figure 2 Map of the study villages showing the Kilombero River (dotted area), DSS area (diagonal hatched area), roads (solid line), railway (crossed lines), and Selous game reserve (dark, horizontal shading). MCH, Mother and Child Health; HC, Health Centre.

Clinical examinations

Each respondent was examined to assess gestational age. Women were given advice by the study nurse about any suspected complications that were detected during the examination and travel allowances given if referral to the district hospital was required. Presence or absence of a pretreated socially marketed net or any other net was confirmed during the physical examination of women recruited in their own homes, or when delivering drugs to the homes of women recruited at the clinic.

The haemoglobin level of each woman was determined at the time of interview using a portable β–haemoglobin photometer (Hemocue©, HemoCue AB, Ängelholm, Sweden) and women with Hb < 11 g/dl were given standard first-line treatment [ferrous sulphate (200 mg twice daily) and folic acid (5 mg once daily) for 2 weeks and chloroquine phosphate (10/10/5 mg/kg)]. Thick and thin blood films were made on-site and a 1-ml capillary blood sample collected from each woman into a microtainer coated with anticoagulant (EDTA) and transported back to IHRDC laboratories at 4 °C.

Laboratory procedures

On the same day as interview the thick blood films were stained with Giemsa and the number of malaria parasites per 200 leucocytes counted. The following day results were available and first line treatment (chloroquine phosphate, 10/10/5 mg/kg) for women positive for malaria was distributed. Sickling and red cell morphology tests were also carried out: the results will be presented elsewhere.

Data processing and statistical analysis

All data were entered twice and consistency checks were done in Foxpro version 2.6 (Microsoft Corporation, Seattle, USA). Data analysis was done in Stata version 6 (Stata Corporation, TX, USA). Proportions were compared using χ^2 tests. Geometric mean parasite densities were calculated and Student's *t*-test was used for comparing means. Logistic regression was used to calculate adjusted odds-ratios for factors influencing ITN ownership and use with age, gravidity, marital and education status, access to cash and household work status entered in a multivariate model for prediction of ITN use. Protective efficacies for the use of ITNs were calculated as (1 – relative risk) × 100.

A household was defined as those people the respondent is currently living with, normally comprised of immediate family members. All respondents said that they lived in households where self-owned land was farmed. Household economic activities were categorized as (1) only working on own farm; (2) working on own farm and on other farms during the planting/harvest seasons; (3) working on own farm and owning a shop or kiosk; (4) working on own farm and on other farms and owning a shop or kiosk.

ITN 'non-users' could both be women not using a net at all or women using an untreated net. Unfortunately, it is not yet possible to test the netting for insecticide content in the field (Drakeley *et al.* 1999), and the responses regarding the treatment of nets other than the KINET nets could not be validated.

Results

Study population

During the study period, 671 pregnant women were identified. Of these, 507 were interviewed, and 505 (75%) had complete data on ITN use. The 164 missing women were made up of 97 (14%) who had already delivered, 36 (4%) who moved away before they could be recruited to the study, 14 (2%) who had aborted, 14 (2%) who could not be traced and 3 (0.4%) who died before recruitment. Mean gestational age was 30 weeks.

The demographic and socio-economic characteristics of the study population and their associations with ITN use in pregnancy are shown in Table 1. More women were using ITNs during the last 3 months of the project (early dry season), as expected given the ongoing promotion of ITNs. Eighty-one per cent (407/505) of pregnant women lived in households which had at least one net. Fifty-seven per cent (289/505) were living in households where there was at least one ITN, 66% of these (191/289) having only one ITN, 26% (75/289) two ITNs, and 8% (25/289) three or more. Fifty-three per cent (266/505) of respondents said that they themselves regularly slept under an ITN and 53% (142/266) of these ITNs had been treated less than 6 months previously. Median time since last washing an ITN was 6 weeks (interquartile range 3–14 weeks).

ITN use and purchasing power

ITN use in pregnancy was positively associated with being aged 20–39 years, being multiparous, having own cash income, being married or cohabiting, and living in a household with a shop or kiosk ($P < 0.05$). Having some primary education was also associated with ITN use with borderline significance ($P = 0.06$).

When all variables in Table 1 were put into a logistic regression model no single variable achieved significance at the 5% level. However, the adjusted odds ratios for primary education [odds ratio (OR) 1.4], having own cash income (OR 1.7), being married (OR 1.6), and living in a household with a shop or kiosk (OR 1.6) were close to significance and differed little from the crude odds ratio. Multiparous women were more likely to have their own cash income than primiparous (66 *vs.* 47%: χ^2 test: $P = 0.001$) and were more likely to be married (89 *vs.* 53%: χ^2 test: $P < 0.001$). When asked what the main reason was for not using an ITN, 92% (465/505) of women said lack of money was the main obstacle.

When asked who was most likely to provide the money to buy an ITN within the household, 88% (334/379) of those currently married said their husband, and the remainder of those currently married said they themselves were the most likely to find the money. Amongst cohabiting women 53% (21/40) said they were the most likely person followed by their partner 30% (12/40) or a parent 17% (7/40). Forty-four per cent of those not currently in a union (39/86) would use their own money and 48% (41/86) thought their parents were most likely to provide the money to buy an ITN, 7% (6/86) felt that no one would buy an ITN.

ITNs and malaria in pregnancy

Twenty-nine per cent (147/505) of women had peripheral parasites on the day of interview. Parasitaemia was twice as common in primigravidae as in multigravidae (56 *vs.* 23%: $P < 0.001$) and more common in second trimester pregnancies than in the third trimester (35 *vs.* 25%: $P = 0.02$).

Fewer ITN users had parasitaemia than ITN non-users (25 *vs.* 33%: $P = 0.06$) (Table 2). When analysing the impact of ITNs on women who had been exposed to malaria, defined as those women currently positive for

Table 1 Association between demographic and socio-economic factors with insecticide-treated nets (ITN) use in the Kilombero Valley, OR, odds ratio; CI, confidence interval

	Variable	Women *n* (%)	ITN use (%)	Predictors of ITN use	
				Crude OR (CI)	Adjusted OR† (CI)
	All women	505 (100)	53		
Age	15–19 years	115 (23)	40	1.0	1.0
	20–29 years	235 (46)	57	2.0 (1.2–3.1)**	1.4 (0.8 – 2.5)
	30–39 years	136 (27)	56	1.9 (1.1–3.1)*	1.3 (0.7 – 2.5)
	40–49 years	19 (4)	47	1.3 (0.5–3.8)	1.0 (0.3 – 2.9)
Gravidity	Primigravida	89 (18)	40	1.0	1.0
	Multigravida	416 (82)	55	1.8 (1.1–2.8)*	1.1 (0.6–2.1)
Education	No education	127 (25)	46	1.0	1.0
	Primary education	378 (75)	55	1.4 (0.9–2.1)	1.4 (0.9–2.1)
Income	No access to cash	50 (10)	40	1.0	1.0
	Household cash only	136 (27)	51	1.5 (0.8–3.0)	1.5 (0.7–3.4)
	Own cash income	319 (63)	55	1.8 (1.0–3.3)*	1.7 (0.9–2.8)
Marital status	Not married	86 (17)	40	1.0	1.0
	Married/cohabiting	419 (83)	55	1.8 (1.1–3.0)**	1.6 (0.9–2.8)
Household economic activity	Seasonal farm work	247 (49)	47	1.0	1.0
	Own farm only	103 (20)	55	1.3 (0.8–2.1)	1.4 (0.8–2.3)
	Shop/kiosk	91 (18)	60	1.6 (1.0–2.7)*	1.6 (0.9–2.6)
	Seasonal farm work + shop	64 (13)	58	1.5 (0.8–2.6)	1.3 (0.7–2.3)
Season	Late dry (Sept–Nov)	94 (19)	51	1.0	1.0
	Rainy (Dec–May)	220 (43)	48	0.8 (0.5–1.4)	0.8 (0.5–1.4)
	Early dry (Jun–Aug)	191 (38)	59	1.4 (0.8–2.2)	1.2 (0.7–2.2)

* $P = < 0.05$; ** $P = < 0.01$.
† Age, gravidity, education and marital status, income, economic activity and season were included in the multivariate model.

Table 2 Parasitaemia and anaemia status by insecticide treated nets (ITN) use

	ITN users ($n = 266$) *n* (%)	ITN non-users ($n = 239$) *n* (%)	χ^2 (*P*-value)	RR (95% CI)
Malaria prevalence by ITN use				
Malaria positive	68 (25)	79 (33)	3.4 (0.06)	0.77 (0.59–1.02)
Malaria exposed†	77 (29)	89 (37)	3.9 (0.04)	0.78 (0.61–0.99)
Parasite density by ITN use				
No parasites	199 (75)	161 (67)		1.00
Low density‡	37 (14)	35 (15)		0.88 (0.58–1.34)
High density§	30 (11)	43 (18)	4.7 (0.02*)	0.62 (0.41–0.95)
Anaemia prevalence by ITN use				
Hb < 11 g/dl	192 (72)	195 (82)	6.2 (0.01)	0.88 (0.80–0.97)
Anaemia status by ITN use				
None (> 11 g/dl)	74 (28)	44 (18)		1.00
Mild (> 7.9 < 11 g/dl)	167 (63)	165 (69)		0.88 (0.79–0.98)
Severe (< 8 g/dl)	25 (9)	30 (12)	6.0 (0.01*)	0.62 (0.40–0.96)

* χ^2 test for trend.
† Exposed = parasite positive or taken malaria treatment in last month.
‡ Low density: < median 1081 parasites/μl.
§ High density: > median 1081 parasites/μl.

malaria together with those who had taken malaria treatment in the last month (compared with those negative for malaria who had not taken malaria treatment), the difference reached statistical significance. The protective efficacy for any parasitaemia was 23% (CI 2–41).

There was a trend in prevalence of high density, low density and no parasitaemia by ITN status with ITN users having fewer low and high density infections compared with ITN non-users (χ^2 test for trend: $P = 0.02$). ITNs were most effective in reducing high density infections: the relative risk (RR) of having a high density infection was 0.62 (CI 0.41–0.95) for ITN users compared with non-users, giving a protective efficacy of 38% (CI 5–59) (Table 2).

Geometric mean parasite densities (parasites/μl) were lower among ITN users than non-users [936 (CI 691–1247) *vs.* 1404 (CI 1021–1917): *t*-test *P*-value: 0.06]. There was an almost twofold decrease amongst multiparous ITN users [625 (463–836) *vs.* 1173 (795–1717): *t*-test *P*-value: 0.01].

ITNs and anaemia in pregnancy

Seventy-seven per cent of women (387/505) had mild anaemia (Hb < 11 g/dl) and 11% (55/505) had severe anaemia (Hb < 8 g/dl). Fewer ITN users had mild anaemia than non-users: 72% compared with 82%: $P = 0.01$. There was a trend in prevalence of severe, mild and no anaemia by ITN status (Table 2) with ITN users having less mild and severe anaemia than non-users (χ^2 test for trend: $P = 0.01$). ITNs were effective in reducing both severe (Hb < 8 g/dl) and mild (Hb > 7.9 < 11 g/dl) anaemia: the RR of having severe anaemia was 0.62 (CI 0.40–0.96) and of having mild anaemia was 0.88 (CI 0.79–0.98) for ITN users compared with non-users (Table 2). The use of an ITN therefore reduced the risk of mild anaemia by 12% (CI 2–21) and the risk of severe anaemia by 38% (CI 4–60).

Impact of ITNs as a function of time since last net treatment

Time since last treatment was the lesser of the time either since a net was last treated or the time since purchase of a KINET pre-treated project net.

The prevalence of both malaria and mild anaemia were lowest in women sleeping under nets treated less than 6 months ago, followed by those women sleeping under nets treated more than 6 months ago, and greatest amongst women not using ITNs (Table 3).

Discount voucher system amongst pregnant women

All women were asked about the discount voucher system: only 28% (141/505) of all women had heard of it. Only 10 women (2% of all women, 7% of those who had heard about the system) said that they had been given a discount voucher. Of these 10, eight had already used the voucher at the time of interview. Of the remaining 131 women who had heard about the voucher system but had not been given one, 83 said they did not want one because they could not afford the discounted price, and 32 said they did not need an ITN (of whom 29 were currently using an ITN). Only 5% (8/141) of those who had heard about it said they had not understood how to use a voucher.

Vouchers were a new concept for the population under study. However, given the high attendance at MCH clinics amongst the study participants (97%), it is surprising that only 28% had ever heard about the voucher system. Promotion activities included posters, leaflets, 6-monthly training of IEC resource people in each village, singing dancing theatre groups, video shows, football tournaments and loud speaker publicity, and coverage was expected to be high.

Indeed, the voucher return rate for the KINET implementation area as a whole was 96.5% (7720/8000 vouchers issued between September 1997 and August 2000). Eighty-six per cent of vouchers issued within this study area (1035/1200), during this study period, were used. However, we were unable to find how many of the discounted ITNs were used by eligible persons. Within the DSS area a cluster sample survey of child health was conducted during the final month of this study (August 1999) (Mushi, pers. comm.). The study found that 44% of mothers of children under 5 years had heard about the system and 13% had used a voucher to buy an ITN; these figures are considerably higher than those found

Table 3 Malaria and anaemia status by time since last net treatment

	ITN treated less than six months ago ($n = 142$)	ITN treated more than six months ago ($n = 119$)	No ITN ($n = 246$)	χ^2 test for trend (*P*-value)
Prevalence				
Malaria positive %	23	28	33	5.2 (0.02)
Hb < 8 g/dl %	9	9	13	1.2 (0.2)
Hb < 11g/dl %	68	76	82	9.4 (0.002)

amongst pregnant women in this study (28 and 2%, respectively).

Therefore, one must look for alternative explanations for the findings on this topic. There was circumstantial evidence from the KINET field team that there were problems in the community regarding the voucher system including MCH clinic staff being reluctant to distribute vouchers and even trying to sell the vouchers for their full discount amount. Other reports included shop-keepers refusing to accept vouchers, and vouchers being sold to 'non-eligible' people. It was suggested that as a result of these problems there was a general reluctance in the community to discuss the voucher system. These issues have been qualitatively investigated by the social scientist of the project and analysis is underway. Preliminary findings indicate that some MCH staff did not fully understand the voucher system, many women had heard about it but were not sure how to get a voucher, there was some confusion over eligibility, there were occasional reports of sales agents not wanting to participate in the scheme, and some women felt that other economic burdens had priority over purchasing an ITN (Mushi, pers. comm.). It is likely that in this study the low knowledge and subsequent user rates were attributable to a combination of MCH staff giving vouchers to mothers with young children more than to pregnant women and respondents giving false statements perhaps in the hope of receiving a new voucher or because their voucher had been used by other people.

Discussion

We have found that ITNs reduce anaemia and the prevalence and density of malaria parasitaemia in pregnancy in an area of intense and perennial malaria transmission. Most importantly, ITNs reduce the prevalence of high parasitaemia and severe anaemia by more than one-third. This finding supports studies in other malaria transmission settings (Dolan *et al.* 1993; D'Alessandro *et al.* 1996) with the exception of that from Kilifi in Kenya (Shulman *et al.* 1998).

Table 4 summarizes key published findings to date of the impact of ITNs on malaria and anaemia in pregnancy. Only endpoints presented in more than one study are shown. In all four studies, severe anaemia was lower in the ITN user group than in non-users although only significantly so in The Gambia dry season study. Mild anaemia was significantly reduced in Tanzania and Thailand (all three sites, based on the incidence of haematocrit < 30%) and not reported for the Gambia. A reduction in peripheral parasitaemia was seen in Tanzania ($P = 0.06$), from the

Table 4 Review of key findings from studies investigating the impact of ITNs on malaria and anaemia in pregnancy

	% Severe anaemia	% Mild anaemia	% Peripheral parasites	% Placental parasites	Mean birth weight (ITN/no ITN)
Thailand†; Dolan *et al.* (1993)					
ITN		**No net/ITN:**	**33**		
No ITN		**RR:2.00**	**59**		
Gambia‡ *(rains);* D' Alessandro *et al.* (1996)					
ITN	17		**22**		**+130 g**
No ITN	20		**36**		–
Gambia‡*(dry);* D'Alessandro *et al.* (1996)					
ITN	**6**		18	20	−135 g
No ITN1	**20**		17	18	–
Kenya§; Shulman *et al.* (1998)					
ITN	15	91	31	72	Similar
No ITN	20	92	35	77	
Tanzania¶; this study					
ITN	9	**72**	25		
No ITN	13	**82**	33		

P-values: Bold indicates $P < 0.05$.

† Three sites, low transmission; mild anaemia = incidence hematocrit < 30%; all pregnancies.

‡ Seasonal high transmission; primigravidae only. Severe anaemia Hb < 8g/dl.

§ High transmission with seasonal peaks; primigravidae only. Severe anaemia Hb < 7g/dl.

¶ Intense perennial transmission; all pregnancies. Severe anaemia Hb < 8 g/dl.

Thai site with the highest transmission intensity, and in the rainy season Gambian study. In the Kenya study the effect of ITNs did not reach statistical significance for any endpoint.

In this study ITNs were being compared with no ITNs and as such the comparison group may have included untreated nets which confer limited protection to the user (Lengeler 2001); this is certain to have resulted in a conservative protective efficacy estimate. However, it should be noted that the protective efficacy for severe anaemia and malaria infection is biased towards older age-groups as young women were least likely to be ITN users and most likely to be severely anaemic or parasitaemic.

Two behavioural changes which deserve attention to optimize the impact of ITNs during pregnancy are apparent. First is the timing of health seeking behaviour during pregnancy. Typically, in this setting women are secretive about a new pregnancy until well into the second trimester: this makes detection of early pregnancies problematic. In our study only one quarter of respondents presented at clinic before 20 weeks gestation. Malaria infection rates are highest in the first half of pregnancy and decrease progressively until delivery (Brabin 1991) and therefore the impact of a malaria prevention tool is not optimized unless used throughout pregnancy. For ITNs this may be achieved over time, once coverage is high in women of child-bearing age, and using an ITN has become normal practice. This, however, was not yet the case in the early phase of our implementation programme.

Second is retreatment of ITNs. Women sleeping under the most recently treated nets had less anaemia and less malaria than those sleeping under nets treated more than 6 months previously. This is particularly pertinent given that the median interval between ITN washes was 6 weeks. Despite intense promotional efforts, retreatment of nets was low (Armstrong Schellenberg *et al.* 2001a). The development of permanently treated nets will address this but in the meantime programmes need to continue promoting and subsidizing net retreatment to both maintain and increase coverage.

The social marketing of ITNs in Tanzania has proven to be a powerful method of implementing a public health tool for the main risk groups. Research on the use of socially marketed ITNs for malaria control in children has found an impact on both mortality (Armstrong Schellenberg *et al.* 2001a) and morbidity (Abdulla *et al.* 2001). Now there is evidence that in this setting pregnant women too are protected by ITNs delivered in this way. In this environment mothers generally sleep with their youngest child and multigravidae may have a net for that child rather than to specifically protect themselves during a new pregnancy. Abdulla *et al.* (2001) found that 61% of children were sleeping under ITNs which is consistent with findings from this study where 55% of multigravidae were using ITNs. Perhaps ITNs could be marketed with a stronger emphasis on their protective benefits during pregnancy for both the mother and unborn child and, given evidence of continued increased susceptibility to malaria of mothers up to 60 days postpartum (Diagne *et al.* 2000), subsequently for both mother and infant after birth.

Uptake of the treated nets has been fast (coverage was estimated to be less than one-third at the start of project and is currently around 60%). However, data from this study would suggest that there are areas in which promotion and targeting could be improved. Women who lived in households where labour on other people's land was one of the main economic activities were less likely to be ITN users. In this area of Tanzania, planting and harvesting main crops are the traditional domain of women even during pregnancy. Farms (*shambas*) may be a long distance from home. During peak activity workers tend to sleep in very small, permeable temporary shelters on the farm and the internal geometry does not suit a normal sized net. Currently in Tanzania research is underway to estimate how many person-years are lived in the *shamba* annually, and what the seasonal patterns are. A low cost treated *shamba* net has been piloted in Rufiji, Tanzania, and proved to be popular under field conditions (de Savigny, pers. comm.).

The majority of the population was able and willing to buy the good quality ITNs that the KINET programme marketed. However, equity must be considered when delivering a public-health tool via social marketing. Indeed, in this study 92% of pregnant women who did not use an ITN said that lack of money was the main problem. This issue is especially pertinent in Tanzania where national scaling-up of ITNs is being implemented with a public/private mix as a strategy to prevent malaria in children (Price Waterhouse Coopers *et al.* 2000).

Furthermore, our results show the importance of targeting all sectors of the population when promoting the use of ITNs by pregnant women and children: most women said that their husband or another family member was most likely to purchase a net in their household. We were not able to say conclusively from this study whether a system such as the discount voucher system, delivered via MCH clinics and as such targeted mainly at women, was an effective means of redressing the economic balance for the poorest. Perhaps the low use of discount vouchers seen in this study was a reflection of women not being the main ITN purchasers. The qualitative research on discount vouchers within the KINET project may reveal more effective avenues to pursue.

Our findings clearly show the impact of ITNs on maternal anaemia and parasitaemia in this area of high transmission. A great additional benefit of protecting expectant mothers is the protection of the newborn children who almost always sleep with their mother in this setting. Both arguments make up a convincing case for including pregnant women as a main target group for ITN promotion.

Acknowledgements

We thank the women who participated in the study; Dr H. Mshinda the Director, and the staff of the Ifakara Health Research and Development Centre for facilitating the study, Drs F. Lwila and P. Mbena (District Medical Officers) and the MCH clinic staff. Ethical clearance was obtained from the Ifakara Health Research and Development Centre and the Tanzania Commission of Science and Technology. Financial support was provided by the Swiss Agency for Development and Co-operation and the Government of Tanzania. T. Marchant is currently supported by a fellowship from the Rudolf Geigy Foundation. C. Lengeler was in receipt of the PROSPER grant 32–41632.94 from the Swiss National Science Foundation. We are grateful to Marcel Tanner for his support, to Clara Menendez and David Schellenberg for comments when developing this study, and to Chris Drakeley and Carine Ronsmans for comments on this paper.

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