LAMBDACYHALOTHRIN TREATED BED NETS AS AN ALTERNATIVE METHOD OF MALARIA CONTROL IN TRIBAL VILLAGES OF KORAPUT DISTRICT, ORISSA STATE, INDIA

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Abstract. A village scale trial was carried out to evaluate the efficacy of bed-nets impregnated with lambdacyhalothrin, at the dose of 0.025 g/m^2, in reducing malaria transmission in villages of Koraput District of Orissa, India, inhabited by tribals. The nets were distributed before peak transmission season. There was an overall decline in the parasite rate in all the age groups, six months after the supply of impregnated nets while the same increased in control village and in a village where untreated nets were supplied. The vector densities (resting and man landing) were lower in the treated village as compared to untreated and control villages throughout the study period. The reduction in the parasite rate was consistent when the reimpregnation was done at six monthly interval and the same tend to increase when the gap between the two impregnations was increased to one year. Though malaria incidence was reduced, transmission was not completely interrupted during the study period, due to outdoor transmission. The insecticidal effect of bednets was retained upto six months. Washing of bednets by the community did not affect the efficacy. The acceptance and usage was better with impregnated nets as compared to ordinary nets.

INTRODUCTION

Malaria control by conventional residual insecticide spray has not yielded desired results in areas with stable endemic malaria, particularly hilly tracts of Orissa State, India, which are inhabited mostly by tribals. Living condition and cultural habits of tribals like half-open housing pattern and frequent mud plastering of walls, refusal to get their houses sprayed and partial exophily of the major vector *An. fluviatilis* are some of the reasons for ineffectiveness of spraying (Rajagopalan and Das 1990; Das *et al,* 1990). Even though use of mosquito nets have been advocated for reducing man vector contact, evidence about the efficacy of this method in reducing malaria is limited (Rozendaal, 1989). Though several trials with insecticide impregnated materials were successful in reducing density of malaria vector, their impact on malaria transmission was assessed in a few places only (Rozendaal, 1989; Jambulingam *et al,* 1989;). Since efficacy of this method will depend upon the insecticide and the attitude of local people, it is necessary to evaluate efficacy of impregnated nets in different areas. Therefore, a village scale trial was undertaken in Koraput District, Orissa, to assess the impact of Lambdacyhalothrin treated bed-nets on malaria trasmission in comparison with protection afforded by untreated nets.

STUDY AREA

Koraput District ($17^0 50'$ and $20^0 30'$ N and $81^0 27'$ and $84^0 10'$ E) is one of the 13 districts of Orissa State, India. The district is hilly and forested and crisscrossed by numerous streams and rivers and has four distinct physiographic zones (Rajagopalan *et al,* 1990). This district is highly endemic for falciparum malaria and all the four human malaria parasite species have been recorded (Jambulingam *et al,* 1989). *Plasmodium falciparum* is the predominant species in all the zones contributing about 90% of the total malaria cases. Annual parasite incidence (API) varies from 3.2 to 67.0 (Rajagopalan and Das, 1990). Southernmost physiographic zone is Malkangiri which is situated at an altitude of 150 m above mean sea level. Climate of this zone is characterized by hot summer (March to June), rainy (July to September) and cold seasons (October to February). Malaria transmission is perennial with a peak incidence in October and November. *An. fluviatilis* is the main vector transmitting malaria throughout the year, biting indoors in all seasons and also outdoors in summer and post rainy season. *An. culicifacies* is the secondary vector prevalent during summer and rainy season (Parida *et al*, 1991).

Three foot-hill villages in this zone namely Bandhaguda (Holdings: 158; Population: 797), Simagudi (Holdings: 87; Population: 429) and Champakhari (Holdings: 73; Population: 368) were selected for the trial which are situated 3 - 5 km apart and apparently similar in socio-economic and malariogenic conditions. The study was carried out from September 1989 to May 1991. Betnets were treated with Lambdacyhalothrin and distributed to villagers of Champakhari and untreated nets to that of Simagudi. Bandhaguda village was kept as control where no net was supplied.

METERIALS AND METHODS

Bed net impregnation and distribution

Nylon nets were preferred because the materials withstand wear and tear and also reported to have the capacity of retaining insecticides on the surface for a longer duration (Rozendaal, 1989). Three sizes of nets with a mesh size of 0.04 cm^2 were selected, single (180 × 90 × 150 cm), double (180 × 135 × 150 cm) and family (180 × 180 × 150 cm) size. They were impregnated with Lambdacyhalothrin (2.5% EC formulation) at the dosage of 0.025 g/m^2 in a centralized laboratory as per standard procedures and precautions (Schreck and Self, 1985), in August 1989. The impregnated nets were allowed to dry indoors. The nets were distributed to villagers according to size of the family, relation between the family members and sleeping habits. Reimpregnation was carried out after six months in February 1990, and one year in February 1991.

Entomological assessment

Pyrethrum spray catches were made from eight fixed catching stations at fortnightly intervals. Outdoor resting collections in artficial and natural pit shelters were carried out fortnightly, from July 1989 to August 1990. Man landing intervals collection was carried out at fortnightly intervals from indoors from 1800 to 0600 hours and outdoors for a specific period of time depending upon the night time activity of the inhabitants of the village. Night resting collection and exit trap collections at fixed catching were also carried out at fortnightly intervals for a period of six months (July 1989 to February 1990). Other house-hold pests and insects, apart from anophelines, that were knocked down by pyrethrum spray were also collected, identified and counted.

All the mosquitos collected by different methods were classified according to species and blood digestion stage. Freshly fed day time resting anophelines were subjected to blood meal analysis. Other mosquitos were dissected for determining parous rate and infection rate. Contact bioassay was carried out, first a week after the bed-nets were installed and subsequently at fortnightly intervals. Twenty engorged females caught from control village were exposed to different parts of the net for 3 minutes. Knock down effect was monitored at 15, 30, 60 minutes and 24 hours after exposure. A similar test was carried out with untreated net for control.

Epidemiological assessment

Mass blood and spleen (2 - 9 years) surveys were carried out in all the villages before supplying bed-nets and subsequently repeated at every six months. Spleen size was graded according to Hackett's method (Bruce Chwatt, 1985). Fortnightly active case detection (ACD) was carried out during the study period and all positives were given radical treatment with appropriate doses of chloroquine and primaquine and were epidemiologically investigated to differentiate between indigenous and imported. Monthly parasite incidence was calculated using the formula : Number positive for malaria parasites out of fever cases/Total population × 1,000. Blood samples were collected by finger prick method from all the infants in the study villages every month and examined for malaria parasites. The infant parasite prevalence was calculated using the formula: Number positive malaria/Total infant population × 100. Parasite density was measured as per standard procedures (Bruce Chwatt 1985).

Sociological observations

As the tribals never used bed-nets before, during the first few months of the study period they were persuaded to use mosquito nets by explaining the benefits of bed-nets usage. Door to door physical verification of nets and inquiries were made at fortnight intervals regarding the use of bed-nets. The details of the causes of non-use of nets, washing frequencies, type of detergent used were also recorded. Season-wise out-door sleeping habit of the villagers was surveyed in the study villages by physically identifying the persons sleeping out-doors.

RESULTS

In Champakari 57 single, 107 double and 24 family size bednets impregnated with lambdacyhalothrin were supplied and in Simagudi 35 single, 91 double and 39 family size ordinary bednets were supplied.

The monthly variation of mean hut densities of *An. culicifacies* and *An. fluviatilis* in the study villages are depicted in Fig 1. The density of *An. culicifacies* shows higher prevalence during summer and rainy months with a peak in June-August after which it declined and remained at a low level during cold months, October-January in all the villages. Though the pattern was the same in all the villages, the density was low through out the study period in treated villages. Since the pre-control density itself was lower than other two villages, the low density could be attributed partly to the treatment of nets and partly to ecological difference between the villages.

A similar trend was also observed in the density of *An. fluviatilis*. However, the density was reduced to zero within one month after the introduction of impregnated nets, and remained at the same level throughout the study period. Whereas in control village density was higher than that of treated village. The mean hut density of other anophelines also showed similar trend.

The indoor man landing rate MLR of *An. fluviatilis* during July to February (Fig 2) showed an increasing trend from October in all the villages, but it was reduced to zero in the treated village in September following the bed-net supply and remained at a lower level for three months.

The indoor MLR of *An. culicifacies* showed a declining trend from September onwards in all the villages. This declining trend was mainly due to seasonal reduction of density. Since this species is zoophilic and the manlanding density was low, it

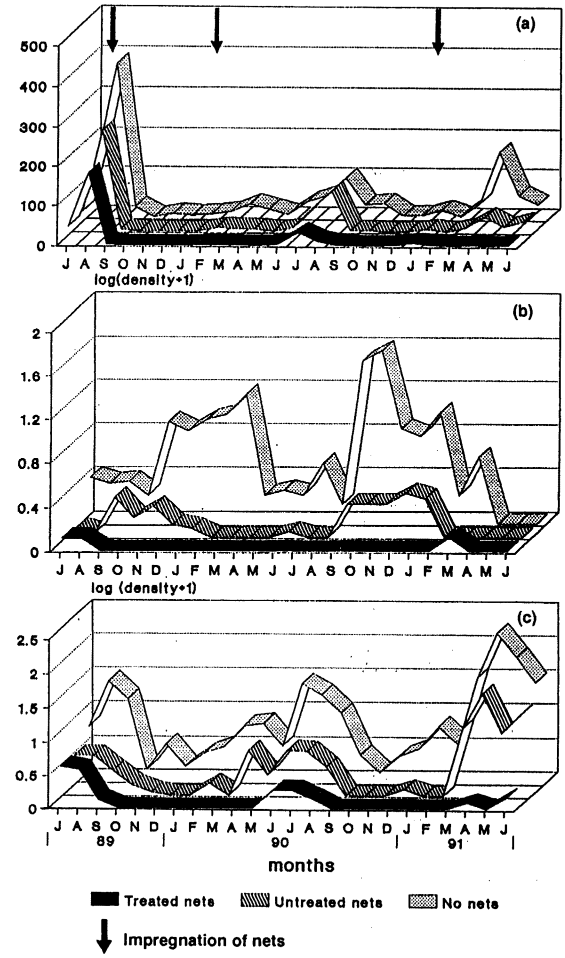

Fig 1—Per hut density of (a) total Anopheline, (b) *An. fluviatilis* and (c) *An. culicifacies* in three villages.

was not possible to evaluate the impact of impregnation on the MLR of *An. culicifacies*. The data on outdoor man landing rate did not give any useful information, since the number collected was very less and no regular biting pattern either for *An. culicifacies* or *An. fluviatilis* was observed as a result of variation in the sleeping habit of the villagers.

The exit traps and outdoor resting collections were not productive because of low density and endophilic nature of the vectors. As the density of *An. culicifacies* and *An. fluviatilis* was very low in treated village throughout the study period, the age structure was not comparable.

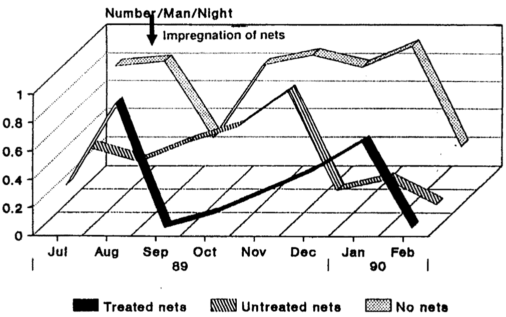

Fig 2—Man landing rate of *Anopheles fluviatilis.*

Analysis of blood meal of *An. fluviatilis* by precipitin test showed that 85.6% out of 277 sampled in control and 82.8% out of 29 in untreated village fed on human. In the treated village, only one fully fed *An. fluviatilis* could be collected throughout the study period, which was positive for human blood. The human blood index of *An. culicifacies* was 3.32% in control, 4.44% in untreated and 2.59% in treated villages. The difference in the anthropophilic index between the study villages was not statistically significant.

The bioassay carried out for 6 months with unwashed and washed nets showed 90 - 100% corrected mortality within one hour (Table 1). Though a few mosquitos survived longer all of them died within 24 hours. Washing of nets did not make any difference in the efficacy.

Epidemiological evaluation

When compared to the results of mass blood survey carried out before the commencement of the trial, there was a decrease in the parasite rate in treated village six months after the introduction of nets, while the same increased in the control and untreated during the corresponding period (Table 2). In the subsequent survey, the parasite rate further decreased in treated village whereas in control and untreated villages it increased. The fourth survey showed that the parasite rate increased in all the villages, but it remained below precontrol level in the treated village. The decrease in parasite load in the treated village was observed in all age groups (Table 3).

While spleen rate in the untreated village remained unchanged the same in control village increased. The spleen rate, in the treated village, declined and remained low till one year and thereafter increase to reach precontrol level (Table 2).

The monthly parasite incidence in the treated village remained at a lower level throughout the

Table 1

Number of *An. culicifacies* exposed to lambdacyhalothrin treated bednets for 3 minutes and mortality in percentage during and after 15, 30, 60 minutes and 24 hours of exposure.

Month	No. of mosquitos exposed	Percentage mortality *				
		3 min	15 min	30 min	60 min	24 hrs
Unwashed net						
Sept, 1989	90	41.1	91.1	100		
Oct	70	11.4	68.5	94.2	95.6	100
Nov	40	25.0	100			
Dec	30	20.0	73.3	83.3	90.0	100
Jan, 1990	30	3.3	63.3	83.3	100	
Washed net						
Oct, 1989	10	0	100			
Nov	40	25.0	100			
Dec	40	12.5	72.5	92.5	100	
Jan, 1990	30	20.0	83.3	93.3	100	

* 100% mortality in 24 hours observation in all months and in both washed and unwashed nets.

Table 2

Results of four mass blood surveys (MBS) carried out at four different time points in three villages.

Parameters	Village	I-MBS (Aug-89)	II-MBS (Feb-90)	III-MBS (Aug-90)	IV-MBS (Feb-91)
Coverage of the total population in percentage	Co	73.5	69.6	65.0	43.9
	Un	65.0	72.9	53.6	40.6
	Tr	76.9	82.0	71.2	51.9
Percent of the sample positive for malaria parasites	Co	21.3	29.9	28.3	35.4
	Un	29.0	38.0	38.3	43.1
	Tr	24.4	11.9	7.2	20.9
% of *P. falciparum*	Co	86.4	81.3	78.9	62.9
	Un	81.5	83.1	77.3	61.3
	Tr	87.1	97.2	73.3	72.5
% of *P. vivax*	Co	6.4	6.6	9.5	18.5
	Un	7.4	5.8	10.2	18.7
	Tr	11.4	2.7	26.3	17.5
% of *P. malariae*	Co	0.8	1.2	3.4	1.6
	Ut	4.9	1.6	1.1	1.3
	Tr	0	0	0	5.0
% of mixed infections	Co	6.4	10.8	8.1	16.9
	Ut	6.2	9.2	11.4	8.0
	Tr	1.4	0	0	5.0
Gametocyte carriers (%)	Co	12.0	13.8	13.6	19.2
	Ut	17.3	17.6	19.3	30.4
	Tr	14.3	19.4	10.5	27.6
Spleen rate (2 - 9 years)	Co	25.8	41.0	43.0	27.6
	Ut	20.0	19.2	12.0	76.5
	Tr	22.5	12.0	12.0	22.03
Average enlarged spleen	Co	2.1	2.1	1.9	2.1
	Ut	1.7	1.7	1.2	1.84
	Tr	1.4	2.0	1.6	1.85

Co = Village where no nets were supplied population 797
Ut = Village where untreated nets were supplied population 429
Tr = Village where treated nets were supplied population 368

study period when compared with village where untreated nets or no net was supplied (Fig 3). However, in the second year there was an increase in the incidence in the peak transmission season, to a level which was comparable to that in control village.

Infant parasite prevalence (IPP) was compared in the three villages for the assessment of interuption of transmission of malaria. The IPP in the treated village remained lower than that of other two villages (Fig 4). The parasites count among the positives in different surveys showed that there was a considerable reduction in heavy infections *ie* three plus and four plus grades, in the treated village in comparison to untreated and control village (Table 5).

Table 3

Parasite rates in different age groups at four different time points in the study villages.

Age group	Period	Champakhari (Treated)	Simagudi (Untreated)	Bandhaguda (Control)
0 - 11 months	Aug 89	11.0	0.0	10.0
	Feb 90	23.0	44.0	43.0
	Aug 90	0.0	0.0	47.0
	Feb 91	0.0	83.0	43.0
1 - 4 years	Aug 89	30.0	48.0	33.0
	Feb 90	12.0	50.0	49.0
	Aug 90	13.5	60.0	49.0
	Feb 91	36.0	77.0	52.0
5 - 9 years	Aug 89	26.0	45.0	34.0
	Feb 90	11.0	52.0	44.0
	Aug 90	8.4	49.0	41.0
	Feb 91	36.0	55.0	55.0
10 - 14 years	Aug 89	25.0	40.0	22.0
	Feb 90	5.0	45.0	29.0
	Aug 90	4.0	37.5	33.0
	Feb 91	12.0	41.0	67.0
15 + years	Aug 89	22.0	18.0	14.0
	Feb 90	13.0	29.0	20.0
	Aug 90	6.0	29.0	18.0
	Feb 91	12.0	26.0	22.0

Pattern of bednet usage

In the village where impregnated bed-nets were supplied, 79% of the population used the bed-nets. In contrast only 38% of the population used the untreated nets. There was a variation in mosquito net use with season. While in rainy season 91.6% and 67.0% used mosquito net in treated and un-

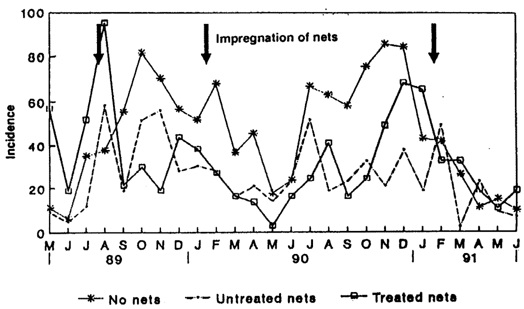

Fig 3—Monthly malaria incidence in three study villages.

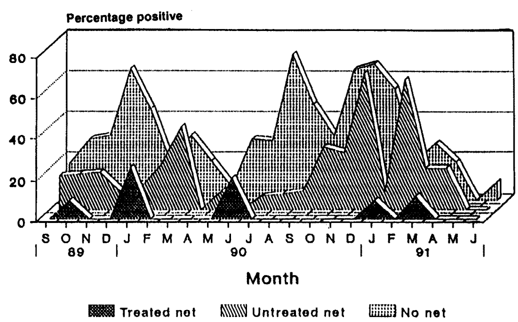

Fig 4—Monthly malaria prevalence among infants in three villages.

Table 4

Parasite densities in different study villages (September 1989 - January 1990).

Parasite grade		Treated n = 55 (%)	Untreated n = 71 (%)	Control n = 208 (%)
+	(1-10 parasites/100 thick field)	17(30.9)	13(18.3)	48(23.0)
+ +	(11-10 parasites/100 thick field)	20(36.3)	14(19.7)	43(20.6)
+ + +	(1-10 parasites/thick field)	12(21.8)	33(46.5)	77(37.0)
+ + + +	(10 parasites/thick field)	6(10.9)	11(15.5)	40(19.2)

treated villages respectively, only 59.5% and 43.0% used in summer and 85.6% and 5.0% used mosquito net during winter, which is the peak transmission season. The bednet usage was higher in all seasons in the village where treated net was supplied (Fig 5).

Only 37% of the treated nets was washed once and 5% of the nets was washed twice. A majority (77%) washed their nets for cleanliness and other 23% as ritual linked with festivals. The majority of them used soda as detergent (75%) and cold water for washing (99%) and 91% sun dried their nets.

In treated and untreated villages nearly 19% of the population slept outdoor in summer season, scantily clothed throughout the night. In winter, 9% of the population slept outdoors in untreated villages near fire and no one slept outdoors in treated villages. In the control village, 31% of the population slept outdoors during summer and 4% of the population did so during winter. Villagers of all age groups and both sexes slept outdoors.

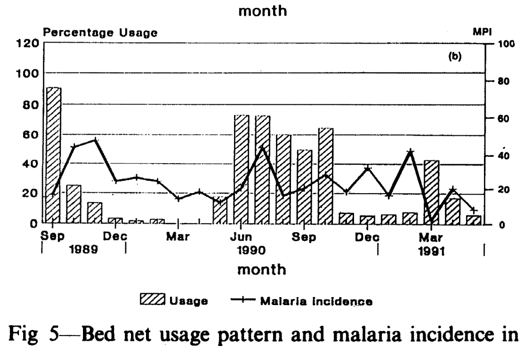

Fig 5—Bed net usage pattern and malaria incidence in (a) village with treated nets and (b) with untreated nets.

DISCUSSION

Work carried out in different parts of the world with deltamethrin and permethrin impregnated bed nets on malaria transmission showed variable results. A village scale trial carried out in Burkina Faso showed that even after one year of introduction of deltamethrin impregnated bed nets, the parasite rates did not differ significantly but the parasite density and morbidity due to malaria reduced significantly (Rozendaal, 1989). Similar results were obtained in Gambia in 1985 and 1987 by Snow *et al* (1988) by using permethrin treated bed nets. However, in a small scale trial with permethrin carried out in Malaysia, a significant effect was noticed in the first month and there was gradual reduction in the efficacy in subsequent months, attributed to poor dosage and acceptance by the community (Ree and Han, 1988). In Papua New Guinea, there was significant reduction in prevalence of *P. falciparum* in 1-4 years age group, but no effect was noticed in *P. vivax* (Millen, 1986).

There has been dramatic reduction of monthly malaria parasite incidence in large scale trials carried out in dirrerent parts of China with deltamethrin impregnated bed nets (Li *et al,* 1987; Xu *et al,* 1988). In these studies, it was observed that there was a downward trend in monthly parasite incidence when compared to the previous year or control village data.

Thus except in China, in other trials there was no change in the overall parasite rate in the community. But significant reduction in morbidity due to malaria and parasite density was observed.

In the present study, the bed-nets were distributed in August just before of the peak transmission season. There was a overall decline observed in the parasite load in all age groups in the next six months and the seasonal increase was considerably reduced in the treated village while the same increased in untreated and control villages. The nets were reimpregnated after six months and the survey showed that the parasite rate was further reduced. The next reimpregnation was done after one year, *ie* in February 1991 and as a result there was an increase in the parasite rate though it was lower than the precontrol level. This suggests that the interval between the two impregnation of nets should be less than one year and with a six monthly interval, the parasite rate could be reduced by more than 50% of the original level. The drastic reduction in spleen rate in the treated village also indicated that there were less frequent attacks due to malaria whereas in the other two villages it was higher. The monthly malaria incidence also showed a decline following the supply of bed-nets. Again, there was an increase in incidence in the second year in the treated village indicating that a one year interval between impregnation of nets was too long to retain the effect of the insecticide. Even though bioassay results showed that insecticidal effect was not affected up to six months, incidence of malaria in some infants during the first six months of the study period indicate that transmission was not interupted completely while the parasite load was reduced considerably. This might be due to outdoor transmission, improper usage of nets, etc. Incidence among infants, however, was lower as compared to that of untreated and control villages. The results of bioassay with washed and unwashed nets and also the number of nets washed by the villagers and the number of times washed indicate that these had little effect on the efficacy of impregnated bednets. Failure to achieve reduction in the prevalence and incidence in untreated village could not be attributed to the unimpregnation alone, as the use of bed-nets was very poor in this village, particularly during winter when the villagers slept near fire due to cold weather. The study demonstrated that the impregnated nets not only are a useful tool for self protection but can also act as vector control agents. Continued use of the nets, reimpregnated at regular intervals may lead to interruption of transmission. Since the hyperendemic condition in this area is maintained by a complexity of factors like vector and host behavior, no single method can be suggested as the appropriate one for control. Impregnated mosquito nets can be considered only as an additional tool to be used by individuals who can afford them. However, to make this acceptable to the community the insecticide should be made available in smaller packs that can be readily used for single or double nets by the community itself. The usage pattern clearly showed that impregnation did improved the acceptability.

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