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Efficacy, Human Safety and Collateral Benefits of Alphacypermethrin Treated Long-Lasting Insecticidal Net (Interceptor®) in a Hyperendemic Tribal Area of Orissa, India

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Abstract

Interceptor net® is a long-lasting insecticidal net (LN) made of multifilament polyester fabric in which the insecticide alphacypermethrin is incorporated directly into the polymers at a dose of 200 mg/m^2. This paper presents the results of an efficacy trial on Interceptor nets on malaria transmission in an area under the influence of pyrethroid susceptible vector species *Anopheles culicifacies* and *A. fluviatilis* in Sundargarh District, Orissa, India. There was a reduction of 57-76% in malaria incidence in Interceptor net area as compared to the control areas. Cross-sectional point prevalence surveys showed a reduction of 73.1% and 40% in malaria prevalence in Interceptor net and untreated net users respectively, whereas there was an increase of 17% in no net villages. The net usage rate in the study population was between 80-98% during different months. With respect to the adverse effects of the insecticide, people reported skin irritations but transitory in nature hence did not pose any danger. Interceptor nets also provided collateral benefits in terms of relief from other household pests such as head lice, bed bugs, cockroaches, ants and houseflies.

Keywords: Long-lasting insecticidal net; Alphacypermethrin; Interceptor net; Human safety; Efficacy trial; Orissa; India

Introduction

Malaria is a serious public health problem, causing an estimated one million deaths each year, predominantly among young children. India reports approximately two-thirds of all confirmed malaria cases in the South-East Asia region. About 95% population in the country resides in malaria endemic areas with five states accounting for 60% of malaria cases: Orissa, Chhattisgarh, Madhya Pradesh, Jharkhand and West Bengal. The National Vector Borne Disease Control Programme (NVBDCP) in India record about 1.5 million cases of malaria annually. 80% of malaria reported in the country is confined to areas consisting 20% of population residing in tribal, hilly, difficult and inaccessible areas. Orissa state located in the eastern part of the country has high burden of malaria and is reporting highest number of total malaria cases, *Plasmodium falciparum* cases and malaria related deaths in the country. In order to meet the challenges for effective malaria prevention and control, the NVBDCP has embarked upon new intervention tools such as replacing chloroquine with Artesunate Combination Therapy (ACT) as a first line of treatment for *P. falciparum*; scaling up of Long-lasting insecticidal Nets (LN) and phasing out conventionally treated Insecticidal Nets (ITN) in the operational malaria control programme in India.

Long-lasting insecticidal Nets (LNs) have been developed to overcome the operational problems of re-treatment of conventional nets (ITN) in the community based malaria control programme in malaria endemic countries [1]. These nets are treated at the manufacturing level with insecticide either incorporated into or coated around fibers, and are resistant to multiple washes. The biological activity lasts as long as the net itself (3 to 4 years for polyester nets, 4-5 years for polyethylene nets). According to World Health Organization Pesticide Evaluation Scheme (WHOPES) a long-lasting insecticidal net should maintain bioefficacy for >95% knockdown and/or >80% mortality against target mosquito vector species for at least 20 serial washings in laboratory and 3 years of continuous use in the field conditions [2]. Fulfilling these criteria, 3 LNs have been given full recommendations and seven brands of LNs including Interceptor® net received interim recommendations from WHOPES for its use in malaria prevention and control [3]. Interceptor® nets manufactured by BASF Chemical Company Limited are 100% texturized multifilament polyester fabric in which the insecticide (alphacypermethrin or FENDONA®) is incorporated directly into the polymers at a dose of 200 mg/m^2. For treatment of the nets, BASF has used FENDOZIN® - a proprietary polymer that forms a thin slow release coating containing the insecticide alphacypermethrin so that the active ingredient diffuses in a controlled manner to the surface of the netting. Interceptor nets have been recently introduced in India and studies on its wash resistance and bioefficacy against local malaria vectors have shown good results [4]. Here, we present the results of a one year field efficacy trial on the impact on malaria transmission, human safety, adverse events and collateral benefits of Interceptor nets in one of the malaria endemic areas of Orissa state in India. The study was approved by the Scientific Advisory Committee as well as Institutional Ethical Committee of the National Institute of Malaria Research, New Delhi.

Materials and Methods

Study area

The detailed description of the study area, selection criteria of study villages, and specifications of Interceptor nets, distribution and monitoring has been published [4]. The study was conducted in three clusters of villages under Gurundia and Birkera Primary Health Centres (PHCs) of Sundargarh district in northern part of Orissa state. The study area was located within a distance of about 25-35 km from Rourkela city and connected by all-weather roads. The study population constituted predominantly ethnic tribal communities with low socio-economic status and living in thatched houses clustered in small hamlets either in the forest area or on deforested land. The nearest medical facilities were situated at a distance of 4 to 6 km. Malaria was a major public health problem in the area. The Annual Parasite Index (API) or number of malaria cases per 1000 population of the Gurundia and Birkera PHC during 2003, 2004 and 2005 were 21.6, 22.6, 25.9 and 47.4, 37.7, 28.1 respectively. Malaria transmission was perennial and *Plasmodium falciparum* accounted for 80-90% of total malaria cases [5,6].

The study villages were short-listed on the basis of epidemiological data available with the Health Centres and also results of the preliminary rapid fever surveys conducted by the study team to get some idea of the number of active malaria cases. On the basis of average incidence rate, sample size of the population for each arm of the study was calculated as ~2000. Therefore, 19 villages were selected, randomized into three clusters and assigned to either LN (Interceptor net) or controls with or without untreated nets. Cluster 1 (Interceptor net) comprised 6 villages (pop. 2314) and cluster 2 (untreated net) had 5 villages (Pop. 2178) and remaining 8 villages with a population of 2204 constituted cluster 3 (no net). The treated and untreated net villages were located in Gurundia block, whereas no net villages were located in Gurundia (6 villages) and Birkera (2 villages) revenue blocks. The demographic information of the study villages was collected through house-to-house census surveys and the data is presented in Table 1. The requirement of the Interceptor and untreated nets for 100% coverage was ascertained through door-to-door sleeping pattern survey in the trial villages. The community owned nets already available in the houses were excluded for estimating the number of nets to be distributed in the study villages.

Study Arm	No. of villages (Houses)	Population		Age group				Total pop.	No. of nets distributed
		Male	Female	0-5	5-10	10-15	>15		
Interceptor net	6 (452)	1161	1153	303	262	251	1498	2314	938
Untreated nets	5 (427)	1100	1078	369	272	235	1302	2178	911
No net	8 (402)	1144	1060	233	335	423	1213	2204	Nil

Table 1: Demographic information of the villages under Interceptor net trial project in Gurundia and Birkera Primary Health Centres, Sundargarh District, Orissa, India

Specifications of Interceptor nets and distribution

Before the start of the trial, community group meetings were organized in the study villages and inhabitants were educated on proper and regular use of nets and importance of the study. The Interceptor nets factory treated with alphacypermethrin at a dose of 0.667% w/w corresponding to 200 mg/m^2 were made of white polyester multi-filaments of 75 denier with 24 holes/cm^2. Plain nets with same specifications were used as untreated control.

The distribution of nets was started in the last week of October, 2006 and completed during November, 2006. The number of nets distributed (Table 1) to each household was recorded in the register and signatures of the recipient were obtained. 938 Interceptor nets and 911 untreated nets were distributed in cluster 1 and 2 respectively so as to cover entire population of these clusters. The population-net ratio of about 2.5:1 was recorded in both the Interceptor and untreated net villages. The population- net ratio was worked out keeping in view the comfort of two adults and a child sleeping under a family size net. A village committee consisting of *panchayat* members (Governing council) and other opinion leaders was constituted in Interceptor and untreated net villages to monitor proper use and maintenance of mosquito nets.

Data generation

The baseline data was collected from August to October, 2006 and intervention data was generated from November, 2006 to July, 2007. The following studies were conducted.

Active case detection

Malaria incidence in the study villages was measured through active surveillance beginning August, 2006. The project staff visited each household once a fortnight and collected finger-prick blood from all individuals reporting fever and prepared thick and thin smears from finger-prick blood. All the slides were brought to NIMR, field station, Rourkela for detection and identification of malaria parasites. Blood slides were stained with Jaswant Singh Bhattacharjee (JSB) stain [7] and examined under oil immersion microscopy for malaria parasite. All slide-positive cases were provided antimalarial treatment as per guidelines of the National Vector Borne Disease Control Programme (NVBDCP), Government of India. Malaria patients with *P. falciparum* were administered chloroquine at a dose of 25 mg/kg body weight (taking visual weight) in three divided doses of 10 mg/kg on day 1, day 2 and 5 mg/kg on day 3, and a single dose of primaquine 45mg on day 1. *P. vivax* and *P. malariae* cases were treated with chloroquine at a single dose of 10 mg/kg body weight followed by a daily dose of 15 mg primaquine for 5 days. This was the standard regimen of malaria treatment as per Indian National Drug Policy during the study period.

However, the drug policy was changed in 2010 and chloroquine was replaced with ACT (AS+SP) as first line of treatment for *P. falciparum*.

The case definition for the diagnosis of malaria and the criteria fixed for a malaria episode were (1) clinical indication by the axillary temperature ≥ 37.5°C, (2) presence of asexual forms of malaria parasite in the thick blood smear, (3) clinical response to antimalarial drugs, and (4) apparent absence of any other disease responsible for the fever. A second episode of fever occurring within 28 days of a first episode was considered to be the result of a recrudescence and not considered a new episode of malaria. Malaria parameters (parasite index {PI: malaria cases/1000 population}, slide positivity rate {SPR: percentage of malaria positive slides}, slide falciparum rate {SFR: percentage of slides positive for *P. falciparum*}, attack rate: population/*P. falciparum* cases) were calculated for each treatment.

Cross-sectional malaria prevalence surveys

Cross-sectional malaria prevalence surveys were conducted in all the study villages during pre-intervention (August-September, 2006) and intervention period (June-July, 2007). The schedule for malaria prevalence surveys was announced one week in advance. 30% of the houses in each village were selected randomly and all the occupants of these houses were included in the survey. Blood smear was prepared from finger prick blood from each individual, irrespective of any clinical symptoms. Persons found positive for malaria parasites during cross-sectional surveys were treated with anti-malarial drugs as described above.

Human safety evaluation

Human safety of the Interceptor nets was evaluated in a cohort of 109 individuals using the nets. The persons enrolled in the cohort study were medically examined by medical practitioners during pre-exposure (day 0) and subsequently during post-exposure period on day 1, day 2, any day between 3-29, day 30 and day 35. The details of medical examination of each individual were recorded on a structured questionnaire.

Compliance rate of net usage, adverse events and collateral benefits

The use rate of Interceptor nets and untreated nets was determined by direct observations through randomly selected household surveys and recording the actual number of individuals sleeping under the nets. Cross-sectional surveys were also conducted among Interceptor net users using a structured questionnaire for assessing their perception about the net usage, adverse events and collateral benefits.

Results

Impact on malaria incidence/prevalence

The impact of Interceptor nets on malaria incidence was measured through longitudinal active surveillance at fortnightly intervals in the trial and control villages. Comparison of malaria incidence data showed that during pre-intervention period of August to October, 2006, the Monthly Parasite Index (MPI) or number of cases per 1000 population in the Interceptor villages was 19.4 and in the control villages with untreated nets and no nets was 20.2 and 22.6 respectively (Table 2). There was no significant difference in the malaria endemicity in the trial and control villages (P>0.05). During intervention phase, the malaria incidence in the Interceptor villages had come down. The Parasite Index (PI) in the Interceptor net, untreated net and without net population was 16.4, 40.4 and 71.7 respectively. Comparison of parasite index between three arms of the study during intervention phase revealed a reduction of 57-76% in malaria incidence in Interceptor net area as compared to the control areas. The difference in malaria incidence in Interceptor net villages is statistically significant in comparison to untreated net and no net villages (P<0.001). The difference in the malaria incidence between untreated net and no net villages was also significant (P<0.001). The month wise parasite index in the trial and control villages is shown in Figure 1. During intervention phase, monthly parasite index in the Interceptor net area was ranging between 0-10.4, whereas it was in the range of 0.5-13.3 and 4.5-15.0 in the untreated net and no net areas. The attack rate of *P. falciparum* or number of episodes per person during intervention phase in different age groups also showed significant reduction in Interceptor net area as compared to untreated net and no net areas (Figure 2).

Study arm	BSE	Total malaria cases	Pf	SPR	SFR	PI
Pre-intervention (Aug-Oct., 2006)						
Interceptor nets	148	45	41	30.4	27.7	19.4*
Untreated nets	152	44	43	28.9	28.3	20.2*
No nets	174	50	49	28.7	28.2	22.6*
Intervention (Nov. 06 – July, 2007)						
Interceptor nets	267	38	34	14.2	12.7	16.4**
Untreated nets	244	88	85	36.1	34.8	40.4**
No nets	362	158	141	43.6	39.0	71.7**

Table 2: Malariometric indices in the villages with Interceptor Nets (TN), Untreated Nets (UN), and No Net (NN) during pre-intervention and intervention phase.

BSE: Blood slides examined; Pf: *P. falciparum*; SPR: Slide positivity rate; SFR: Slide falciparum rate; PI: Parasite index (No. of malaria cases per 1000 population).

*P>0.05 (insignificant)

**Significance of difference during intervention: TN vs. UN=P <0.001; TN vs. NN=P<0.001;

UN vs. NN=P<0.001

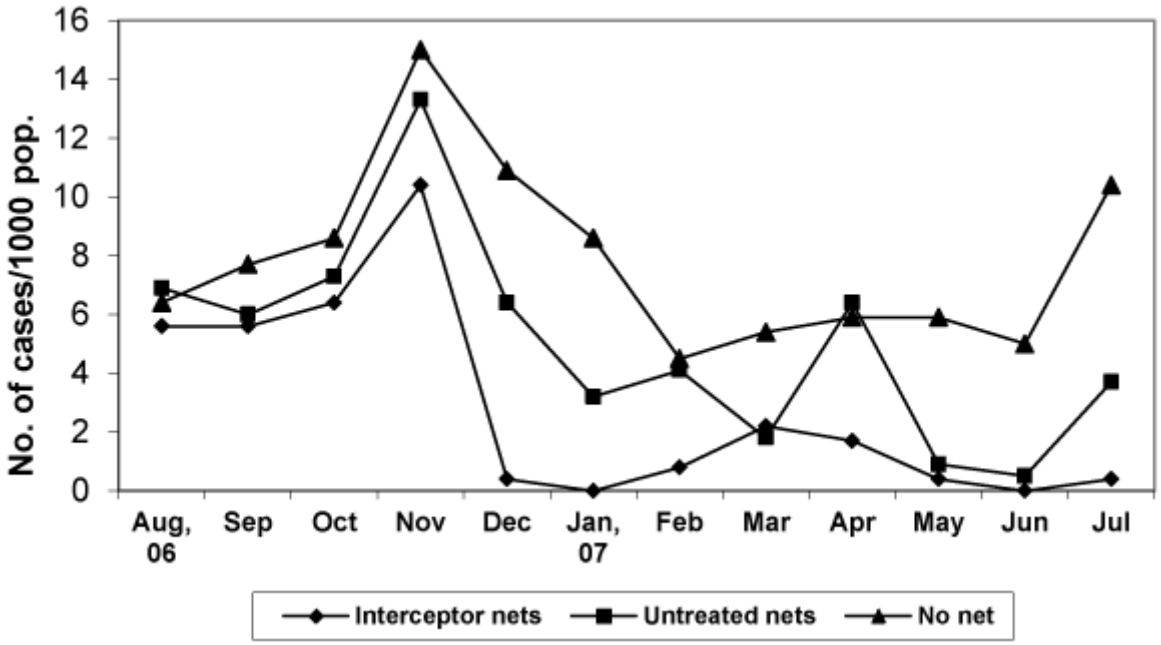

Figure 1: Month-wise malaria incidence in the study population using Interceptor nets, untreated nets and no net during pre-intervention (August-October, 2006) and intervention phase (November, 2006-July, 2007)

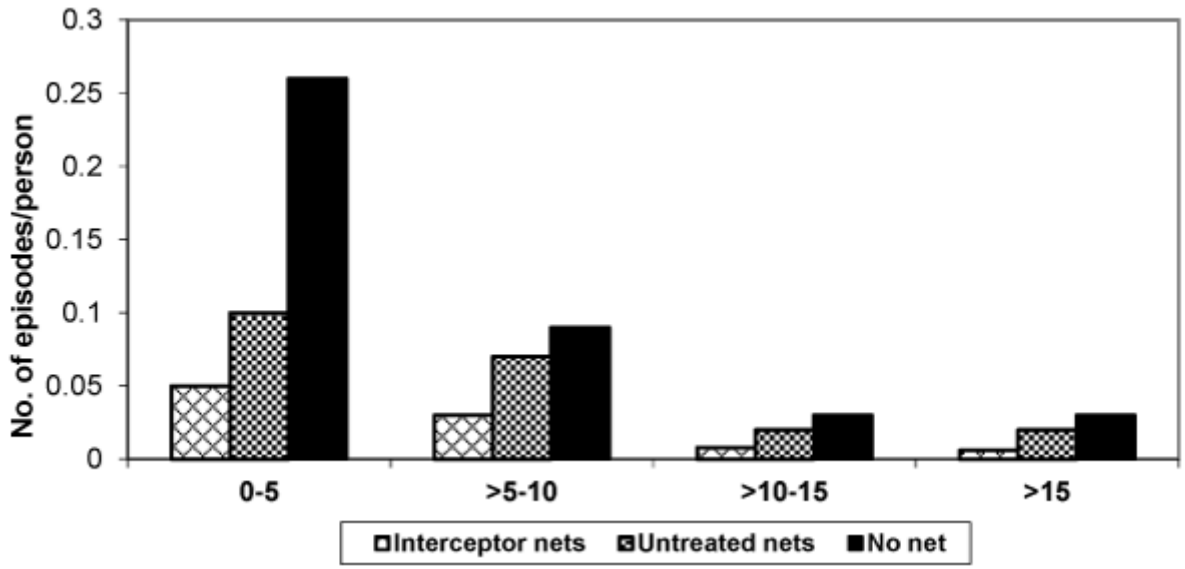

Figure 2: Attack rate of P. falciparum malaria in different age groups using Interceptor nets, untreated nets and no net during intervention phase (November, 2006 to July, 2007)

Malaria prevalence in the study villages was measured through cross-sectional point prevalence surveys. The cross-sectional surveys during pre-intervention phase were carried out during August-September, 2006 and during intervention phase in the months of June-July, 2007. Both the periods of cross-sectional surveys coincides with the monsoon season and thus unlikely to affect prevalence rate on seasonal basis. The parasite rate or % of individuals positive for malaria parasite in Interceptor net, untreated net and no net population during pre-intervention was 6.7, 6.0 and 5.8 respectively and no significant difference was observed between all the three clusters. During intervention phase the parasite rate in Interceptor net users had come down to 1.8, whereas in untreated net and no net

users, the parasite rate was 3.6 and 6.8 respectively (Figure 3). Comparison of parasite rate in Interceptor net villages during intervention with that of pre-intervention period showed that there was 73.1% reduction in malaria prevalence, which was statistically significant (P<0.001). Malaria prevalence in untreated net area also showed a significant reduction of 40.0% in comparison to pre-intervention phase (P<0.01), whereas there was an increase of 17% in no net villages, which was insignificant (P>0.05).

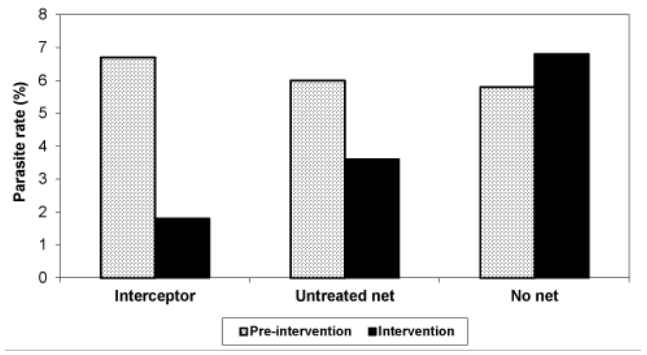

Figure 3: Malaria prevalence in the population using Interceptor nets, untreated nets and no net during pre-intervention and intervention phase as recorded through cross-sectional surveys

Human safety of Interceptor nets

Human safety of the Interceptor nets was evaluated in a cohort of individuals using the nets. 109 persons of different age groups ranging between 5 to 60 years were enrolled in the study out of which 101 completed the study and rest were lost to follow ups. The details of medical examination of each individual were recorded on a structured questionnaire and the summary findings are reported in Table 3. On pre-exposure (day 0) of medical examination, few people reported illness of varied reasons such as fever (14%), weakness (11%), nausea (3%), vomiting (6%), diarrhea (8%), headache (4%), dizziness (1%), wheeze (6%), cough (9%), lacrimation (4%) and skin related infections (1%). The blood smears were prepared from the fever cases and were given presumptive radical treatment as per national drug policy in high risk areas. Medical prescription was also given to those persons suffering from other ailments. On subsequent follow up as per schedule, most of the illnesses reported on D-0 were resolved by D-2 and none of the participants reported other ailments except for minor skin irritation/itching reaction (5%) on day 1 and 1% on day 2. However, no adverse event was observed that may be attributed to the use of Interceptor nets.

Observations (N = 109)	Pre-Exposure (Day 0)	Exposure days				
		D1	D2	D3 - D29	D30	D35
I. General						
Fever	14	1	1	0	0	0
Weakness/ Fatigability	11	11	11	0	0	0
Sweating	N	N	N	N	N	N
Reduced sleep	0	0	0	0	0	0
II. Gastrointestinal						
Nausea/ vomiting	9	0	0	0	0	0
Appetite	1	N	N	N	N	N
Abdominal Pain	3	0	0	0	0	0
Diarrhea	8	1	1	0	0	0
III. Neuromuscular						
Headache	4	1	1	0	0	0
Dizziness	1	0	0	0	0	0
Irritability	0	0	0	0	0	0
Twitching	0	0	0	0	0	0
Paraesthesia	0	0	0	0	0	0
IV. Cardio-respiratory						
Wheeze	6	1	0	0	0	0
Cough	9	4	4	0	0	0
Expectoration	3	0	0	0	0	0
Tightness of Chest	0	0	0	0	0	0
V. Eye						
Lacrimation	4	2	1	1	0	0
Blurred vision	0	0	0	0	0	0
VI. Vital signs						
Blood pressure	N	N	N	N	N	N
Pulse/min	N	N	N	N	N	N
Temperature 0C	N	N	N	N	N	N
VII. Skin						
Dermal reaction/ irritation/ allergic reaction	1	5	1	0	0	0
Any other abnormal reaction	NAD	NAD	NAD	NAD	NAD	NAD

Table 3: Results of medical examination conducted at different day's interval in a cohort of net users to assess human safety of Interceptor nets.

N=Normal, NAD=Nothing abnormal detected

Compliance rate, perceived adverse events and collateral benefits

There was 85-98% compliance rate of Interceptor net usage in the study population during different months. The use rate of untreated nets in the control villages was between 80-95% in different months. Cross-sectional surveys were conducted among 280 adults (Males-161, Females-119) using Interceptor net to assess their perception on protection from malaria and mosquitoes, the adverse events and collateral benefits of using Interceptor nets (Table 4). 98.2% of the respondents asserted that they are sleeping under the Interceptor net. There were complains of skin irritation (20.7%), itching (10%), headache (1.4%) and eye irritation (1.8%). However, these effects were only transitory in nature lasting for few hours of the first usage. Majority of the respondents also reported that they are feeling relief not only from mosquitoes but also from other household pests such as head lice, bed bugs, cockroaches, ants and houseflies.

S.No.	Questions	% Users (N=280)
1.	**Do you know why mosquito nets are used**	100
2.	**Do you know that nets were provided for personal protection in your house**	100
3.	**Are you using any other indigenous method for Mosquito control**	5
4.	**Do you sleep inside the Interceptor nets**	98.2
5.	**Did you suffer any of the following**	
	Skin irritation	20.7
	Nausea	0
	Vomiting	0
	Itching	10.0
	Headache	1.4
	Drowsiness	0
	Eye irritation	1.8
	Difficulty in breathing	0
	Any other	0
6.	Do you feel suffocation while sleeping inside Interceptor net	3.5
7.	Do you fear of poisoning for using Interceptor net	0
8.	**Observations/perceptions about collateral benefits**	
	Reduction in mosquito bites	90.4
	Reduction in nuisance due to bedbugs	26.8
	Reduction in nuisance due to head lice	51.4
	Reduction in nuisance due to house fly, ants and cockroaches	25.4

Table 4: Cross-sectional survey for perceived adverse events and other collateral benefits among Interceptor net users in experimental villages of the Sundargarh district

Discussion

Malaria is a disease deeply affected by social and economic conditions and is referred to as a disease of the poor and a cause of poverty. The marginalized, poorer sections mostly rural and tribal with low socio-economic status, limited access to quality health care, communication, other basic facilities, lack of awareness on protection measures, are often the worst sufferers. Keeping in view the disease determinants and limited resources, the Global Malaria Control strategy emphasized the need for selective and sustainable preventive measures of vector control for reducing malaria problems [8]. To achieve this objective, insecticide treated mosquito nets can contribute because it revolves around the community based action oriented programme. Untreated mosquito nets were reported to provide some protection against malaria and mosquitoes [9] but cannot give complete protection against mosquitoes [10]. Therefore, the protective effect of mosquito nets may be enhanced by impregnating the fabric with an insecticide such as synthetic pyrethroids [11]. A number of field efficacy trials in India have shown the usefulness of insecticide

treated nets in reducing malaria morbidity in different eco-epidemiological situations [12-15]. The recently introduced long lasting insecticide treated mosquito nets are designed to maintain their biological efficacy against vector mosquitoes for at least 3 years under recommended conditions of use in the field. When tested in the laboratory, the insecticidal efficacy of the nets should persist through at least 20 standard washes [2].

The present study revealed that Interceptor nets-a long-lasting insecticidal net factory treated with alphacyperrmethrin are effective personal protection intervention strategy resulting in significant reduction in malaria incidence and prevalence in the malaria endemic rural areas of Sundargarh district, Orissa, India largely inhabited by ethnic tribal communities. Interceptor nets were found to be wash-resistant and maintained bioefficacy against pyrethroid susceptible malaria vectors *A. culicifacies* and *A. fluviatilis* even after repeated washings [4].

The results of the present trial are based on comparative data collected from three different cluster of villages using Interceptor nets, untreated nets and no nets over a period of one year during malaria transmission season. The study villages located over short geographical distances were homogenous in terms of ethnicity, socio-economic status and malaria endemicity. The malaria incidence in the three cluster of study villages during pre-intervention phase was similar. During intervention, malaria incidence reduced significantly in villages with Interceptor nets whereas there was no significant reduction in the untreated net and no-net control villages. However, comparison between untreated net and no net showed that malaria incidence was significantly lower in villages with untreated net, therefore, indicating that untreated nets do provide partial protection from malaria. In Sub Sahara Africa, where the vector is resistant to pyrethroids, no difference was found between the treated net user and non-user groups with regard to the percentage of children exhibiting *P. falciparum* trophozoites or gametocytes or to the mean parasite load. However the rate of high density parasitemia and malaria attacks was twice as high in the non-user group [16].

In the present study, the attack rate due to *P. falciparum* was significantly lower in all age groups sleeping under Interceptor nets as compared to those using untreated net or no net. The attack rate was also lower in population using untreated nets in comparison to no net users. The attack rate in no net users showed that younger age groups were more vulnerable to malaria attack and clinical episodes decreased with age as reported earlier [6]. Although the incidence of clinical attacks due to *P. falciparum* malaria in population using Interceptor nets were significantly lower as compared to untreated nets and no net, no significant difference was found in attack rates in population using untreated nets and no nets except children up to 5 years of age. Similar findings have been reported with conventionally treated nets from rural area of the Gambia, West Africa [17,18]. In western Kenya, use of permethrin impregnated bed nets reduced incidence of *P. falciparum* infections by 40%-48% in children less than six years old [19]. In rural area of Zanzibar with very high perennial transmission, permethrin impregnated bed nets led to a 74-78% reduction in the weekly rate of reinfection with malaria parasites in all age groups [20].

A significant reduction was also recorded in the malaria prevalence in the population using Interceptor nets as compared to untreated net and no net users. In an earlier trial with the tablet formulation of deltamethrin in Sundargarh district, Orissa, a significant reduction was found in spleen rate and parasite rate in children who had used treated nets but did not find any significant change in these parameters in children from untreated and no net villages [14].

The use of LNs, is one of the cheapest and most effective interventions against malaria. In a recent analysis of the cost of ITN/LN and IRS (indoor residual spraying) programmes in Africa, LNs were found to be significantly cheaper to use than conventionally treated nets [21]. For LNs lasting 3 years, the costs per death averted and per DALY (disability-adjusted life year) averted were less than half those for conventional ITNs. The study's findings also suggest that, in high-transmission areas, where most of the malaria burden is carried by children less than 5 years of age, and assuming that LNs can be effectively targeted to this population group, the use of LNs is four to five times cheaper than IRS which cannot be targeted to children alone. The annual cost per LN averaged US$ 2.10 (range 1.48–2.64), which corresponds to US$1.05 per person protected per year [21].

The outcome of the bed net trials largely depends on the compliance rate of the net usage by the study population. The compliance rate in the present trial was fairly good during most part of the year, which was an important factor for better parasitological results. The population acceptance and use of Interceptor nets was also enhanced by the fact that LNs provide other collateral benefits in terms of relief not only from mosquitoes and malaria but also from other household pests such as head lice, bed bugs, cockroaches, ants and houseflies [22]. The full coverage and high usage rate also had a "mass effect" on the vector populations resulting in the herd-protection effects against malaria in the Interceptor net villages as compared to untreated and no net villages. A study has shown that relatively modest coverage (30-60%, depending on the ecological scenario) of all adults and children can achieve equitable, community-wide benefits [23]. Thus, the long-lasting insecticidal nets provide protection for everyone in the community, even people who do not sleep under a net themselves [24].

There is no safety concerns associated with synthetic pyrethroids because the recommended concentration of the insecticide for treatment of mosquito nets is quite safe [25]. The available data from various field trials have proved the overall effectiveness of long-lasting insecticidal nets in preventing malaria infection regardless of study location and local vector species. Long-lasting insecticidal nets have been strongly advocated to reduce malaria transmission and are increasingly in demand for use in health systems to target high-risk population groups [26,27]. Moreover, the strategy is simple and cost-effective compared to indoor residual spraying. The introduction of long-lasting insecticidal nets in a community based intervention programme is operationally feasible to contain malaria especially in the high transmission difficult areas where other interventions have limited role.

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