Transactions of the Royal Society of Tropical Medicine and Hygiene 105 (2011) 327–332

Contents lists available at ScienceDirect

Transactions of the Royal Society of Tropical Medicine and Hygiene

journal homepage: http://www.elsevier.com/locate/trstmh

Downloaded from https://academic.oup.com/trstmh/article-abstract/105/6/327/1892599 by University of Oxford user on 24 April 2020

Malaria control in a forest fringe area of Assam, India: a pilot study

P. Dutta*, A.M. Khan, S.A. Khan, J. Borah, C.K. Sharma, J. Mahanta

Regional Medical Research Centre (ICMR), Northeastern Region, Dibrugarh 786001, Assam, India

ARTICLE INFO

Article history:
Received 29 May 2009
Received in revised form 21 February 2011
Accepted 21 February 2011
Available online 6 May 2011

Keywords:
Malaria
Disease vectors
Anopheles
Insecticide-treated mosquito nets
Insect repellent
India

ABSTRACT

A study was conducted to evaluate the preventive efficacy of insecticide-treated mosquito nets (ITMNs) and mosquito repellent (MR) in a malaria-endemic foothill area of Assam, India, with forest ecosystem. During the first year, a survey was conducted in four demarcated sectors (A–D) to observe the malaria endemicity and vector prevalence patterns before implementing intervention measures. All four sectors were endemic for malaria. The prevalence of established malaria vectors such as *Anopheles dirus*, *A. minimus* and *A. philippinensis* was observed. During the second year, intervention measures were implemented in the four sectors as follows: A, ITMN + MR; B, ITMN; C, MR; D, no intervention. The most effective intervention was in sector A, followed by sectors B and C. Sectors A and B exhibited significantly higher ($P < 0.001$) malaria protective efficacy during both the first and second years of intervention compared with sector D. The total vector population in the three intervention sectors decreased significantly compared with that of the non-intervention one. Information–education–communication activities motivated the residents to participate actively in the intervention programme. The finding could be an effective model for containment of high malaria morbidity in inaccessible forest fringe areas of the northeastern region of India.

© 2011 Royal Society of Tropical Medicine and Hygiene. Published by Elsevier Ltd. All rights reserved.

1. Introduction

A study published by WHO in 1986[1] revealed that the northeastern region of India is highly endemic for *Plasmodium falciparum* malaria, along with foci of a chloroquine-resistant strain. Two highly anthropophilic mosquito species, *Anopheles balabacensis* (re-described as *A. dirus*)[2], a forest-breeding mosquito, and *A. minimus*, which breeds in slow-flowing streams, are regarded as chief vectors of malaria in this region.[3–5] *Anopheles philippinensis*, which breeds in swamps and rice fields and is a predominant species in this region, is also seen as a potential vector for transmission of malaria.[6,7] There is an abundance of ideal breeding sites for *A. dirus*, *A. minimus* and *A. philippinensis* in northeastern India.

Previous studies have shown that a higher percentage of *P. falciparum* malaria, including chloroquine-resistant *P. falciparum*, exists in forest fringes and foothills.[8,9] It has also been reported that chloroquine can enhance infection of chloroquine-resistant *P. falciparum* in *A. balabacensis*.[10] If this happens in northeastern India it could have serious consequences for malaria treatment and control.

Source reduction and environmental control strategies are a challenge. The impregnation of mosquito nets with synthetic pyrethroids to reduce the incidence and prevalence of malaria has received much attention.[11–13] This study was conducted to investigate the efficacy of insecticide-treated mosquito nets (ITMN) and mosquito repellent (MR) in controlling malaria incidence, as well as to determine the acceptability of bed nets among the different ethnic populations of northeastern India. The information will be of use when planning and implementing

* Corresponding author. Tel.: +91 373 2381494/2381566, +91 99544 30865(mobile); fax: +91 373 2381494/2381548.
E-mail address: duttaprafulla@yahoo.com (P. Dutta).

0035-9203/$ – see front matter © 2011 Royal Society of Tropical Medicine and Hygiene. Published by Elsevier Ltd. All rights reserved.
doi:10.1016/j.trstmh.2011.02.008

future malaria control strategies for endemic areas of northeastern India.

2. Materials and methods

2.1. Study area and population

The study was carried out during 2003–2006 in Bokakhat Primary Health Centre which constitutes 11 sectors comprising a population of 179 422. It lies in Golaghat district bordering the Karbi Anglong hill district of Assam state, India, and has a unique forest–foothill ecosystem. The participating population was 7200 in 1200 households. The majority of dwellings are made of bamboo with mud-plastered walls. Most of the populace are subsistence farmers, although a few households depend upon manual labour in forest-related activities. Men and women are usually engaged in paddy cultivating and harvesting activities during the spring and summer. Habitually, people are early risers (04:30–06:30 h) and also go to bed early (20:00–22:00 h). They are accustomed to using bed nets. During collection of baseline information, it was observed that the bed nets in use were of inferior quality and possession of nets for families was inadequate.

2.2. Study design

Four sectors, A, B, C and D (with an intersector distance of about 15–20 km), were earmarked for the study. These sectors are of a similar ecological setup (forest-fringe foothills) and are located along the border of Karbi Anglong district, with a uniform malaria endemicity pattern [slide positivity rate (SPR) in the range 24.52–32.40; source: Directorate of Health Services, NVBDCP, Guwahati, Assam state, India]. During the first year of the study, active door-to-door surveillance of malaria was conducted to get the true incidence of the disease in all four sectors. After 1 year of data collection for the baseline study (July 2003 to June 2004), implementation of intervention measures was initiated in the four sectors as per the study protocol from July 2004 onwards, and a follow-up study was then undertaken.

Intervention measures in the four sectors were: Sector A (297 households with a population of 1782) had ITMNs and MR; Sector B (303 households with a population of 1818) had ITMNs alone; Sector C (306 households with a population of 1836) had MR alone; and Sector D (294 households with a population of 1764) had no intervention. Information–education–communication (IEC) activities were carried out in sectors A, B and C by organising exhibitions and lecture sessions in schools and community halls to encourage the proper use of ITMNs and MR. A pamphlet in the local language regarding malaria (causes, prevention, etc.) was prepared and distributed among schoolchildren and villagers. Active door-to-door surveillance was continued in all four sectors to obtain comparable data on malaria incidence patterns after implementation of the intervention strategies.

2.3. Entomological and parasitological baseline and follow-up

A team consisting of three to five technical people accompanied by a parasitologist/entomologist/clinician collected the demographic, parasitological and entomological data through cross-sectional active surveys in each study sector. Initially a house-to-house survey was made to enumerate the houses and population and to collect information about their caste, religion, occupation, lifestyle and knowledge about malaria. Subsequently, active parasitological surveillance was conducted by surveillance workers at weekly intervals in door-to-door visits for collection of blood films from all fever/febrile cases detected in the study sectors. Fever cases were first registered, and information on age, sex, name of the patient, name of the village, history of malaria, complaints of illness, drugs already taken, etc. were noted. The blood slides were properly stained and examined under a microscope in the field laboratory. Active surveillance continued throughout the year. The SPR (no. of malaria-positive cases/no. of fever cases $\times$ 100) was calculated for each sector for comparison. All malaria-positive cases were treated with antimalarials according to the species of parasite present. Malaria morbidity was quantified by taking the number of cases positive for malaria parasites (SPR). Entomological surveys were conducted by operating CDC miniature light traps fortnightly inside the index human dwellings throughout the night in each sector to monitor the anopheline vector density pattern. Light traps were fixed in index houses around dusk and after a whole night of operation were collected in the morning. Trapped mosquitoes were transferred to Barraud cages with the help of suction tubes and were transported to the field laboratory. They were identified by following identification keys.[14–17] Anopheline collections were recorded monthly for each sector.

2.4. Mosquito nets and repellent

All sectors were surveyed and houses enumerated for distribution of mosquito nets. Considering the activity period of the regional malaria vectors in the area, bed net distribution was completed by July 2004. The bed nets used were nylon-156 mesh (12 $\times$ 13 holes/square inch) (M/s Amsa Exports, Tamilnadu, India) and were impregnated with deltamethrin EC, 20–25 mg/m^2 trade name, K-Othrine; Bayer India Ltd., Gurgaon, Haryana, India according to the technique recommended by WHO.[18]

The number of nets distributed was proportional to the size of the households and their family structure, ensuring that all family members of marked houses received an ITMN as per their requirement. Follow-up visits to the study areas were carried out during the evening hours to inspect the proper use of supplied bed nets (six surprise checks every month in each intervention sector). The nets were re-impregnated during the second year of observation in June 2005.

The MR used was N,N-diethylbenzamide 12% w/w. Cream-base tubes (25 mg) (commercial name, Odomos; Balsara Home Products Ltd., Kanpur Dehat, Uttar Pradesh, India) were distributed among households of the

Downloaded from https://academic.oup.com/trstmh/article-abstract/105/6/327/1892599 by University of Oxford user on 24 April 2020

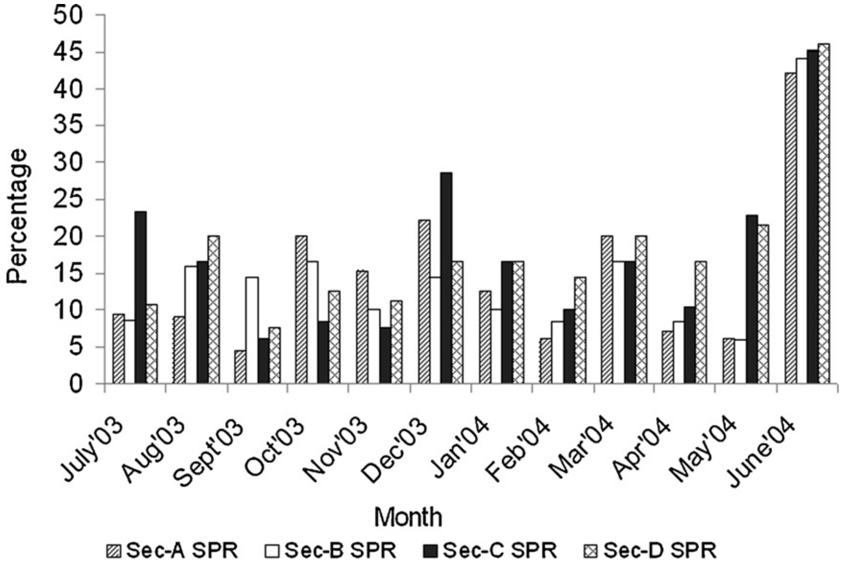

Figure 1. Malaria incidence patterns before intervention in four study sectors (A–D) in a forest fringe area of Assam, India. Sec-A: insecticide-treated mosquito net (ITMN) and mosquito repellent (MR); Sec-B: ITMN alone; Sec-C: MR alone; and Sec-D: no intervention. SPR: slide positivity rate.

earmarked sectors (two tubes per person to use for a month). The proper use of MR (on exposed parts of the body) was monitored through unannounced 'sniff checks' during the evening hours.

2.5. Statistical analysis

Statistical analyses were performed to compare malaria protective efficacy: (1) of the intervention sectors (A, B and C) versus the non-intervention one (D); and (2) within the intervention sectors [both (1) and (2) were analyzed using EpiInfo 6.1 (CDC, Atlanta, GA, USA) to test the statistical significance among the variables under study]. The abundance of vectors in intervention versus non-intervention sectors was compared using a *t*-test.

For each sector the risk ratio indicates the difference in malaria morbidity relative to the reference group. A risk ratio greater than 1 indicates a higher effectiveness of the given treatment relative to the reference group; the *P*-value indicates the significance level for the interaction term. A significant interaction term indicates that the risk ratios were significantly different between the sectors.

3. Results

3.1. Malaria surveillance and entomological observations in pre-intervention phase

In the pre-intervention phase, after parasitological monitoring, it was observed that all four sectors were endemic for malaria. The SPR recorded in A, B, C and D sectors was in the range 4.52–42.19, 5.88–44.03, 6.25–45.23 and 7.69–46.15, respectively (Figure 1). Thus the parasitological survey depicted a similar prevalence pattern of malaria in all four sectors.

Similarly, with regards to the entomological observations conducted during the pre-intervention year, the presence of 16 species of *Anopheles* in human dwellings was documented. In sector A, out of a total of 878 collections during the year, a monthly average of 73.16 anophelines was recorded; in sector B, out of 1224 collections, a monthly average of 102.0 anophelines was recorded; in sector C, out of 989 collections, a monthly average of 82.41 anophelines was recorded; and in sector D, out of 919 collections, a monthly average of 76.58 anophelines was recorded. The percent composition of recognised vectors among the total anophelines collected was *A. dirus* 2%, *A. minimus* 7% and *A. philippinensis* 8%. *Anopheles dirus* was detected during the months of July to November, whereas *A. minimus* and *A. philippinensis* were prevalent throughout the year. It was observed that the preponderance of anophelines in terms of vectors as well as non-vectors in all four sectors were of a similar pattern (Figure 2).

3.2. Parasitological monitoring in intervention phase

The effectiveness of the intervention measures was most prominent in sector A, followed by sectors B and C. The relative effectiveness in reduction of malaria morbidity was prominent in sector A, which was about 3.5 times higher in the first year and five times higher in the second year compared with that of sector D, the non-intervention sector. Both sectors A and B were found to have a higher malaria protective efficacy, which was statistically significant, in comparison with that of sector D (non-intervention) ($P < 0.001$). Although sector C exhibited some protective efficacy, this was not significant during either the first or second years of observation (Table 1).

Comparison of the 2 years of intervention showed that the benefit in terms of reduction of malaria cases was more in the second year than in the first year (Table 1).

Comparison of malaria morbidity patterns among the intervention sectors showed that in the first year of intervention, malaria morbidity was 28 and 68% lower in sector

Downloaded from https://academic.oup.com/trstmh/article-abstract/105/6/327/1892599 by University of Oxford user on 24 April 2020

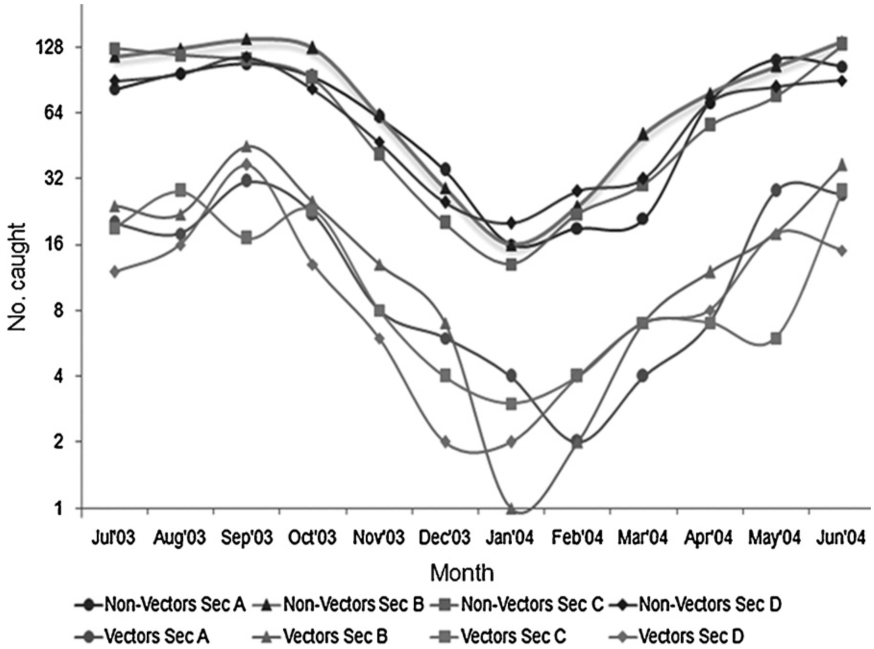

Figure 2. Number of anopheline vectors and non-vectors collected before intervention in four study sectors (A–D) in a forest fringe area of Assam, India. Sec A: insecticide-treated mosquito net (ITMN) and mosquito repellent (MR); Sec B: ITMN alone; Sec C: MR alone; and Sec D: no intervention.

A than in sectors B and C, respectively, whereas in the second year it was 32 and 77%. The differences were statistically significant ($P < 0.001$) in sector C in both the first and second years of intervention (Table 2).

3.3. *Indoor density of potential vectors in post-intervention phase*

The anopheline population in terms of vectors and non-vectors in both sectors A and B showed a drastic decline after intervention during the first and second years of observation, whereas in sectors C and D, no noticeable reduction was observed (Figure 3). The total population of potential vectors in indoor collections was significantly lower ($P < 0.001$) in intervention sectors (A, B and C) than in the non-intervention sector (D) after intervention during the first and second years of observation (Table 3).

3.4. *Monitoring of proper use of ITMNs*

During surprise checks on the proper use of ITMNs at night, it was observed that almost all families in the intervention sectors accepted the measure of using ITMNs. Initially, some people reported a feeling of suffocation while sleeping under an ITMN and some of them were found to sleep with their head protruding out of the net. However, motivation was effective in changing their habit.

4. Discussion

In the present study, it was observed that, of the three different intervention measures, ITMNs + MR were the most effective in preventing malaria, followed by ITMNs alone and MR alone. Increased effectiveness of multiple intervention measures was noted in a study carried out in the Solomon Islands.[19] In entomological monitoring, it was found that the total anopheline density, including the major vectors *A. dirus*, *A. minimus* and *A. philippinensis*, in human dwellings in intervention sectors (A and B) declined drastically in comparison with that of the non-intervention sector (D). In sector C, where only MR was used, no such reduction in the anopheline population like that in A and B was observed because the cream-base repellent for skin use has no direct effect in reducing indoor mosquito density; rather it can reduce the human biting ratio. In other studies, insecticide-treated nets were found to be effective

Table 1
Comparison of the protective efficacy of intervention measures on malaria morbidity in intervention and non-intervention sectors in a forest fringe area of Assam, India

Intervention sector	1st year of intervention (2004–2005)		2nd year of intervention (2005–2006)	
	Risk ratio	*P*-value	Risk ratio	*P*-value
A: ITMN + MR	3.63 (2.27–5.79)	<0.001	5.14 (2.78–9.50)	<0.001
B: ITMN alone	2.63 (1.74–3.96)	<0.001	3.49 (2.07–5.88)	<0.001
C: MR alone	1.16 (0.85–1.58)	NS	1.20 (0.83–1.72)	NS
D: none	1		1	

ITMN: insecticide-treated mosquito net; MR: mosquito repellent; NS: not significant.

Downloaded from https://academic.oup.com/trstmh/article-abstract/105/6/327/1892599 by University of Oxford user on 24 April 2020

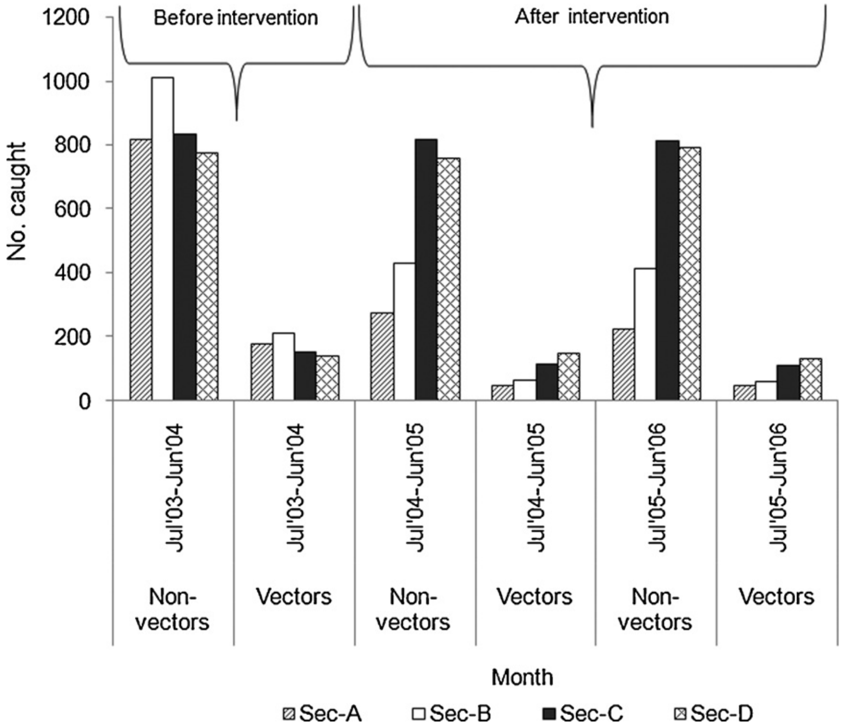

Figure 3. Number of anopheline vectors and non-vectors collected before and after the intervention in four study sectors (A–D) in a forest fringe area of Assam, India. Sec-A: insecticide-treated mosquito net (ITMN) and mosquito repellent (MR); Sec-B: ITMN alone; Sec-C: MR alone; and Sec-D: no intervention.

Table 2
Comparison of the protective efficacy of intervention measures on malaria morbidity within three intervention sectors in a forest fringe area of Assam, India

Intervention sector	1st year of intervention (2004–2005)		2nd year of intervention (2005–2006)	
	Risk ratio	*P*-value	Risk ratio	*P*-value
A: ITMN + MR	1		1	
B: ITMN	0.720 (0.42–1.25)	NS	0.680 (0.33–1.41)	NS
C: MR	0.320 (0.20–0.51)	<0.001	0.230 (0.13–0.44)	<0.001

ITMN: insecticide-treated mosquito net; MR: mosquito repellent; NS: not significant.

in repelling and killing *Anopheles* mosquitoes.[20,21] Cheng and Heng[11] also observed a marked reduction in the biting anopheline population at the end of their intervention study with ITMNs.

Our study strongly indicates that the use of ITMNs alone or with MR and the implementation of IEC activities simultaneously can control the malaria situation effectively in highly malaria-endemic areas of northeast India,

Table 3
Number of *Anopheles* vectors caught indoors in intervention and non-intervention sectors in a forest fringe area of Assam, India

Intervention sector	Major vector species [range (mean)]				
	A. dirus	*A. minimus*	*A. philippinensis*	Total[a]	*P*-value[b]
1st year (2004–2005)					
A: ITMN + MR	0–2 (0.50)	0–3 (1.17)	0–5 (1.92)	0–9 (3.58)	<0.001
B: ITMN alone	0–3 (1.08)	0–4 (1.67)	0–7 (2.50)	0–11 (5.25)	<0.001
C: MR alone	0–5 (1.58)	0–7 (2.25)	1–14 (5.67)	3–20 (9.50)	<0.001
D: none	0–8 (3.17)	6–25 (13.75)	5–28 (15.42)	11–59 (32.33)	
2nd year (2005–2006)					
A: ITMN + MR	0–2 (0.67)	1–3 (1.67)	0–4 (1.83)	1–9 (4.17)	<0.001
B: ITMN alone	0–3 (1.17)	0–4 (1.75)	0–7 (2.17)	0–11 (5.08)	<0.001
C: MR alone	0–3 (1.33)	1–7 (3.00)	2–10 (5.08)	3–20 (9.42)	<0.001
D: none	0–12 (2.92)	10–21 (16.00)	10–27 (19.67)	21–55 (38.58)	

ITMN: insecticide-treated mosquito net; MR: mosquito repellent.
[a] Total number of major vector species collected during the whole year for each sector.
[b] *P*-values result from pairwise comparison of total no. (range) of vector species with sector D.

Downloaded from https://academic.oup.com/trstmh/article-abstract/105/6/327/1892599 by University of Oxford user on 24 April 2020

where highly anthropophilic vectors such as *A. dirus* and *A. minimus* are prevalent. Because of the exophilic (outdoor-resting habit) nature of *A. dirus*, indoor residual spraying has no direct effect on this vector. The present ITMN intervention study has shown a very good impact in reducing malaria incidence in an area prevalent for *A. dirus*. The use of impregnated bed nets in Laos, where *A. dirus* is the major malaria vector, has similarly shown considerable success in controlling malaria.[22]

It was also observed that malaria protective efficacy was more pronounced in the second year of intervention compared with the first year. This indicates that continuous use of ITMNs and MR may subsequently confer total protection from malaria by eliminating the parasite reservoirs from the community in the long run. Further, the IEC activities were found to be an essential component in the implementation of such intervention strategies in the targeted communities. This enlightened the local populace, who were totally ignorant about malaria, and sensitised them towards this serious health issue, after which they were motivated to accept the measures of regular use of ITMNs. The findings of Collins et al.[23] and D'Alessandro et al.[12] also proved that IEC activity has great implication in preventing malaria when accompanied by intervention measures.

The level of success of protection from malaria given by ITMNs + MR or ITMNs alone and the promotion of their use through IEC activities in the malaria-endemic forest fringe and foothill areas of northeastern India suggests that this multiple intervention strategy can be an effective model for implementation in the national malaria control programme for India. The success of any community-oriented health programme depends on the acceptability of the technology that the community can afford and the health activities the community can carry out. The strengthening of information network systems in such an antimalarial programme and establishment of a strong relationship between community and local authorities can ensure the success of the operation within a short timespan.

Authors' contributions: PD planned and designed the study protocol and drafted the manuscript; AMK and JM carried out the parasitological and clinical assessment and interpretation of data; SAK and CKS carried out the entomological assessment and interpretation of data; JB carried out the statistical analysis and interpretation of data. All authors contributed to the revision of paper and read and approved the final version. PD is guarantor of the paper.

Acknowledgements: The authors are grateful to the health authorities of the state of Assam for their kind cooperation and help during the study period. The excellent technical assistance received from Mr S. Phukan, Mr R. Das, Mr P.K. Doloi, Mr N.K. Baruah and Mr R.C. Doloi is gratefully acknowledged.

Funding: This study was funded by the Indian Council of Medical Research, New Delhi, India.

Conflicts of interest: None declared.

Ethical approval: Ethical clearance was obtained from the Institutional Ethical Committee (RMRC, ICMR, Dibrugarh, Assam, India) and informed consent was taken from the study participants before undertaking the study.

References

1. WHO. *The clinical management of acute malaria*. Geneva: World Health Organization; 1986, Southeast Asia Series No. 9.
2. Peyton EL, Harrison BA. *Anopheles* (*Cellia*) *dirus*, a new species of the Leucosphyrus group from Thailand (Diptera: Culicidae). *Mosq Syst* 1979;**11**:40–52.
3. Bhatnagar VN, Dwivedi SR, Mishra BG, Das M. Detection and incrimination of *Anopheles minimus*, Theobald 1901 as malaria vector in the foothill areas of Nagaland, India. *Indian J Malariol* 1982;**19**:129–33.
4. Dutta P, Bhattacharyya DR, Sharma CK, Dutta LP. The importance of *Anopheles dirus* (*A. balabacensis*) as a vector of malaria in Northeast India. *Indian J Malariol* 1989;**26**:95–101.
5. Dutta P, Bhattacharyya DR, Sharma CK, Dutta LP. Anopheline fauna of parts of Tirap district, Arunachal Pradesh with reference to malaria transmission. *Indian J Med Res* 1992;**95**:245–9.
6. Anderson LAP, Viswanathan DK. *The Assam Medical Research Society, Shillong: a resume of its activities during 1931–41*. Calcutta: Thacker, Spink and Co.; 1941.
7. Rajagopal R. Studies on persistent transmission of malaria in Burnihat, Meghalaya. *J Commun Dis* 1976;**8**:235–45.
8. Kondrashin AV, Jung RK, Akiyama J. Ecological aspects of forest malaria in South East Asia. In: Sharma VP, Kondrashin AV, (eds.). *Forest malaria in Southeast Asia*. Proceedings of an informal consultative meeting; World Health Organization, 18–22 February 1991, New Delhi, p. 1–28.
9. Mohapatra PK, Prakash A, Bhattarcharyya DR, Mahanta J. Malaria situation in Northeastern Region of India. *ICMR Bull* 1998;**28**:21–30.
10. WHO. *The biology of malaria parasites*. Geneva: World Health Organization; 1987, Technical Report Series No. 743, p. 118–20.
11. Cheng H, Hang W. Large-scale spraying of bednets to control mosquito vectors and malaria in Sichuan, China. *Bull World Health Organ* 1995;**73**:321–8.
12. D'Alessandro U, Olaleye BO, McGuire W, Thomson MC, Langerock P, Bennett S, et al. A comparison of the efficacy of insecticide –treated and untreated bed nets in preventing malaria in Gambian children. *Trans R Soc Trop Med Hyg* 1995;**89**:596–8.
13. Binka FN, Kubaje A, Adjui M, Williams LA, Lengeler C, Maude GH, et al. Impact of permethrin impregnated bednets on child mortality in Kassena-Nankana district Ghana: a randomized control trial. *Trop Med Int Health* 1996;**1**:147–54.
14. Ramachandra Rao T. *The anophelines of India*. Rev. ed. Delhi: Malaria Research Centre, Indian Council of Medical Research; 1984.
15. Knight KL, Stone A. *A catalogue of the mosquitoes of the world (Diptera: Culicidae)*. Lanham, MD: Entomological Society of America; 1977.
16. Puri IM. *Synoptic table for the identification of the anopheline mosquitoes of India*. 4th ed. Delhi: Government of India Press; 1955. Health Bulletin No. 10.
17. Wattal BL, Kalra NL. Regionwise pictorial keys to the female Indian *Anopheles*. *Bull Natl Soc Indian Malar Mosq Dis* 1961;**9**:85–138.
18. Schreck CE, Self LS. *Treating mosquito nets for better protection from bites and mosquito borne disease*. Geneva: World Health Organization; 1985. WHO/VBC/85.914.
19. Over M, Bakote'e B, Velayudhan R, Wilikai P, Graves PM. Impregnated nets or DDT residual spraying? Field effectiveness of malaria prevention techniques in Solomon Islands, 1993–1999. *Am J Trop Med Hyg* 2004;**71**:214–23.
20. Sakato LA. National malaria day and malaria awareness walk. Text of an address given on the occasion of the malaria awareness work held in Abuja. *J Mal Afr Trop* 2002;**1**:6–7.
21. Lines JD, Myamba J, Curtis CF. Experimental huts trials of impregnated mosquito nets and cave curtains against malaria vectors in Tanzania. *Med Vet Entomol* 1987;**1**:37–51.
22. Kobayashi J, Phompida S, Toma T, Looareensuwan S, Toma H, Miyagi I. The effectiveness of impregnated bed net in malaria control in Laos. *Acta Trop* 2004;**89**:299–308.
23. Collins KA, Kwadwo K, Cynthia A, Don DS, Mitchell W. Socio-cultural determinants of treatment delay for childhood malaria in southern Ghana. *Trop Med Int Health* 2006;**11**:1022–31.

Downloaded from https://academic.oup.com/trstmh/article-abstract/105/6/327/1892599 by University of Oxford user on 24 April 2020