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# Cross-border malaria control for internally displaced persons: observational results from a pilot programme in eastern Burma/Myanmar

**Adam K. Richards[1,2], Kristin Banek[2], Luke C Mullany[2,3], Catherine I. Lee[2], Linda Smith[2], Eh Kalu Shwe Oo[4] and Thomas J. Lee[2,5]**

1 *Department of General Internal Medicine and Health Services Research, University of California, Los Angeles CA, USA*
2 *Global Health Access Program, Berkeley CA, USA*
3 *Center for Public Health and Human Rights, Johns Hopkins Bloomberg School of Public Health, Baltimore MD, USA*
4 *Karen Department of Health and Welfare, Mae Sot, Tak, Thailand*
5 *Department of Medicine, University of California, Los Angeles CA, USA*

**Summary**

OBJECTIVES To document the feasibility of a cross-border community based integrated malaria control programme implemented by internally displaced persons in eastern Burma/Myanmar.

METHODS This pilot study was conducted from February 2003 through January 2005 in seven villages of displaced ethnic Karen. Interventions comprised early diagnosis of *Plasmodium falciparum* and treatment with mefloquine and artesunate, distribution of long-lasting insecticide treated nets (LLITNs), and educational messages. The primary outcome measure was *P. falciparum* prevalence during bi-annual universal screenings with the Paracheck-Pf® (Orchid Biomedical Systems, Goa, India) device. Secondary outcomes were *P. falciparum* incidence and process indicators related to net use and malaria knowledge, attitudes and practices (KAP).

RESULTS *P. falciparum* prevalence in original programme areas declined from 8.4% [95% confidence interval (CI) 8.3–8.6] at baseline to 1.1% (95% CI 1.1–1.2) in the final screening. Annual incidence in original areas declined from 232 to 70 cases/1000/year [incidence rate ratio 0.30 (95% CI 0.24–0.39)]. The proportion of household members sleeping under a LLITN improved from 0% to 89% and malaria KAP improved in all areas.

CONCLUSIONS Integrated malaria control organized and implemented by displaced persons is feasible in eastern Burma/Myanmar. The decline in *P. falciparum* prevalence and incidence suggest that it may be possible to reduce the burden of disease and the reservoir of malaria in eastern Burma/Myanmar, with implications for malaria control in the greater Mekong region.

**keywords** malaria, internally displaced persons, refugees, Burma, Myanmar, community

## Introduction

Multiple interventions with proven efficacy to control malaria exist, but evidence for effective implementation strategies in areas of active conflict is lacking. This implementation gap is particularly acute in Burma/Myanmar (hereafter 'Burma'), where poor access to treatment and widespread drug resistance (Wongsrichanalai *et al.* 2001; Zhou *et al.* 2005; Carrara *et al.* 2006) is reflected in the highest malaria case fatality rate (3%) and greatest number of annual malaria deaths reported in southeast Asia (WHO 2005a). Actual malaria morbidity and mortality are likely much higher than official estimates (WHO 2006), particularly in ethnic border regions (Socheat *et al.* 2003; Beyrer *et al.* 2006).

Despite international consensus on the imperative to improve malaria control along the Thai–Burma border (Beyrer & Lee 2008), restrictive policies of Burma's military government have constrained the humanitarian space available to international organizations operating from within the country (Beyrer *et al.* 2006). As a result, most malaria programmes have been limited to the Thai side of the border, where currently there are no large-scale internationally funded malaria programmes targeting internally displaced people (IDP) in eastern Burma.

By the end of 2004 there were an estimated 526 000 IDPs in eastern Burma and at least 240 villages had been destroyed, forcibly relocated, or abandoned in the two preceding years (Thailand Burma Border Consortium 2004). Retrospective mortality cluster surveys in this

population documented infant (89 per 1000 live births) and child (218 per 1000 live births) mortality rates well above reported national rates (Lee *et al.* 2006; Mullany *et al.* 2007). To meet basic healthcare needs, approximately 95 000 IDPs rely largely on a network of 32 clinics run by the Karen Department of Health and Welfare (KDHW) (Beyrer *et al.* 2006; Lee *et al.* 2006; Lee 2007). Due to the precarious security situation, health workers participate in trainings conducted along the Thai–Burma border and must hand-carry supplies to villages in Burma.

Extensive evidence supports the effective use of early diagnosis and treatment (EDT) with artemisinin combination therapy (ACT) in refugee camps along the Thai–Burma border (Rowland & Nosten 2001), and in rural communities adjacent to Burma using Thai community health workers (Carrara *et al.* 2006). This report documents the feasibility of a cross-border malaria control programme implemented by a community-based organization with a unique ability to navigate the constrained political and ecologic landscape of eastern Burma, and its impact on *P. falciparum* prevalence during the programme's first 2 years.

## Materials and methods

### Study population

Karen (Kayin) State is a forested hilly area of eastern Burma bordering Thailand, with a 6-month rainy season (May–October). Information on entomology and malaria epidemiology in this area is limited, although ecologically similar areas of Thailand experience two seasonal peaks in transmission (in June/July and December). Official data from Burma suggest that *Plasmodium vivax* (approximately 20%) and *Plasmodium falciparum* (approximately 80%) account for the vast majority of malaria cases in the country (Myanmar Department of Health Planning 2006). The predominant mosquito vectors (*Anopheles dirus*, *A. minimus* and *A. maculatus*) in this region display early biting times, exophagic and exophilic behaviours that complicate vector control (Carrara *et al.* 2006; Oo 2003; Trung 2005). Cluster surveys in a population of over 225 000 in conflict areas of Karen State estimated the mean prevalence of *P. falciparum* between 2004 and 2006 to be 10.2% (Richards *et al.* 2007); and suggest that malaria may contribute to 45% of all deaths (Lee *et al.* 2006).

This pilot study was conducted from February 2003 through January 2005 in seven villages of internally displaced ethnic Karen (Figure 1). Of the four original villages (population 1868), two (Po Bu La Hta and Ler Per Her) were located directly on the Thai border and two were located in more remote areas. In February 2004 the programme was expanded to include three more villages: two (Klaw Gaw and New Ler Per Her, population 1218) within 30 min walking distance of Po Bu La Hta and Ler Per Her, and a more remote village (Mae Ngaw, population 347), without clinic access, which was added to determine the feasibility of programme implementation where EDT was not available.

### Programme design

Based on the Roll Back Malaria recommendations, the programme comprised EDT, long-lasting insecticide-treated nets (LLITNs), and educational messages. Universal screening was conducted at 6-month intervals to estimate the primary outcome (prevalence) and to potentially reduce the number of asymptomatic carriers (Macauley 2005). KDHW coordinated and planned all trainings and supplies, with technical support from the Global Health Access Program, an international non-governmental organization. In each village, malaria committees composed of village leaders, health workers and lay persons played a central role in all programme activities.

### Early diagnosis and treatment

Management of clinically suspected malaria cases followed the Burma Border Guidelines (Aide Medicale Internationale 2003), a consensus document developed by regional organizations including the Shoklo Malaria Research Unit. Febrile patients were tested for *P. falciparum* malaria using the Paracheck-Pf® device (Orchid Biomedical Systems), the locally-recommended histidine-rich protein 2 antigen based rapid diagnostic test (RDT). Ler Per Her also had access to a microscope with a mirror light source. Confirmed episodes of *P. falciparum* parasitaemia were treated immediately with a 3-day course of mefloquine and artesunate unless contraindicated. Febrile patients testing negative for *P. falciparum* were treated for presumptive *P. vivax* with chloroquine. Primaquine was not administered due to the 10–15% prevalence of glucose-6-phosphate deficiency and risk of haemolytic disorders documented in other areas of Burma (Guthmann *et al.* 2008). All treatments were directly observed unless the patient was travelling outside the village.

### Long lasting insecticide treated nets

At the inception of the programme (Term 1) 1–2 long-lasting insecticide treated nets [LLITNs; DawaPlus Tana Netting Co. (by SiamDutch) Ltd, Bangkok, Thailand] were distributed free of charge to each household. After

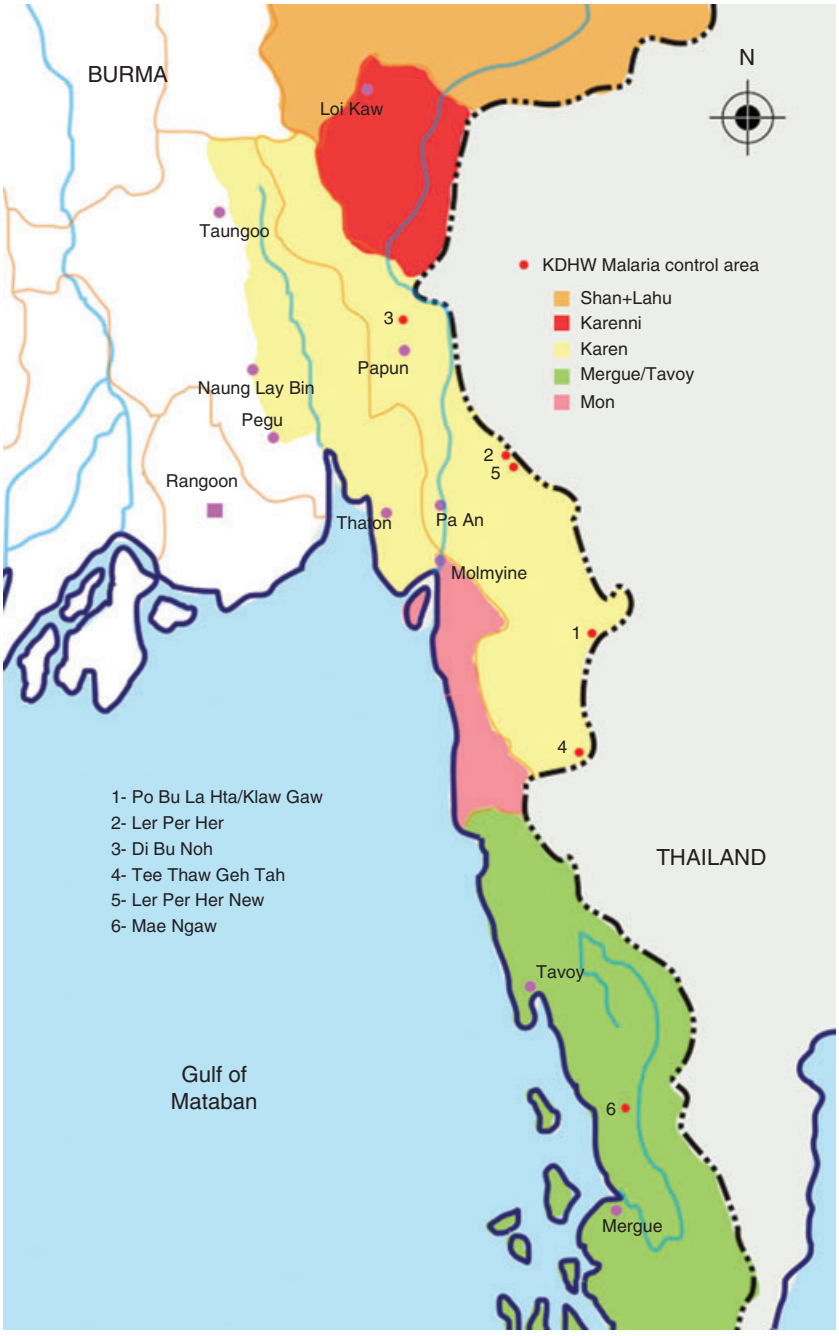


**Figure 1** Map of eastern Burma, indicating Karen Department of Health & Welfare (KDHW) malaria programme areas.

6 months households with four or more people received another LLITN.

### Bi-annual screening and treatment

In early 2003 and every 6 months thereafter, health workers screened the entire population of each village for *P. falciparum* using RDTs. After a population census that counted the number of individuals in each household, villagers were either tested at the clinic or during house-to-house screenings. All villagers testing positive were treated according to local guidelines. The first and third term screenings were conducted during the dry season, when malaria prevalence in intervention-naive

areas is lower than in the rainy season (Richards *et al.* 2007).

### Education

Focus groups of health workers developed educational malaria messages addressing the causes of malaria, the importance of seeking early treatment for fever, adherence to prescribed medicines, and the safety and use of LLITNs. Community sensitization sessions were conducted at programme initiation, and messages were reinforced during LLITN distribution and monitoring visits. A brief knowledge, attitudes and practices (KAP) survey was administered during bi-annual screenings to assess baseline knowledge and evaluate the educational component of the programme.

### House monitoring

Malaria programme committees selected volunteers with basic enumeration skills to conduct periodic house visits (initially every 2 weeks, tapering to every other month) to monitor net retention and use and to refer febrile villagers to the nearest clinic.

### Primary outcome measurement

Similar to several studies from southeast Asia, the primary outcome measure was the proportion of the screened population with *P. falciparum* parasitaemia (Erhart *et al.* 2004a, b; Huong *et al.* 2002; Hung *et al.* 2002; Incardona *et al.* 2007). Parasitaemia was determined with the Paracheck-Pf® rapid diagnostic test (RDT) during bi-annual screenings, [(number *P. falciparum* positive)/(total number screened)], and overall estimates were weight-adjusted by village population size. Confidence intervals for prevalence estimates were calculated for finite populations to account for near-complete sampling by multiplying the standard error by the square root of $(1-p)$, where $p$ is the sampled proportion of the population [CI = $+/-1.96 \times \mathrm{SE}\sqrt{(1-p)}$].

### Secondary outcome measurement

*Plasmodium falciparum* incidence rates were estimated as the number of incident episodes of *P. falciparum* parasitaemia for each period divided by the mean population recorded in the two most recent bi-annual screenings. Incidence rates were compared between 2003 and 2004. Annual incidence estimates exclude data from Di Bu Noh because it was not possible to disaggregate records from patients presenting from villages outside the programme area. Prevalence and incidence rates were stratified by sex and age (<5, 5–14 and 15+ years). Other secondary indicators assessed included net ownership, net use, and change in KAP scores.

### Data management

Data were collected as part of routine programme monitoring and evaluation. Data forms were entered into a computerized database (Microsoft ACCESS) and cleaned using range and internal consistency checks. *P. falciparum*-positive results for each area and term were verified manually by hand-counting all records. Local leaders of the Burma Medical Association and the National Health and Education Committee of the National Coalition of the Union of Burma (Government-in-Exile) reviewed and approved the programme protocols. The Johns Hopkins University Committee on Human Research approved the secondary analysis of the data. The authors of this paper were responsible for the secondary analysis, conducted with Stata 8.2 (Stata Corp., College Station, TX, USA).

## Results

The population reached, by the programme, increased from 1868 in February 2003 to 3431 in August 2004 (Table 1), with 17% under 5 years old. No malaria-related deaths were reported during the 2-year pilot period.

### Prevalence

Results from bi-annual universal screenings are presented in Figure 2 and Table 2. Screenings were planned for identical months in each year, but security concerns delayed the return of health workers to three programme areas during the dry season of 2004 by up to 1 month. The proportion of villagers surveyed was high (>95%). Prevalence of *P. falciparum* declined from the first to the second screenings in new villages initiating the programme in both 2003 (mean 8.4–3.1%) and 2004 (7.3–0.8%) ($P < 0.001$ for each year). Prevalence remained low in the original four villages in Term 3 (2.2%) and Term 4 (1.1%) ($P < 0.001$ *vs.* baseline prevalence).

### Incidence

Clinical incidence rates are presented in Table 2. Excluding data from Di Bu Noh due to incomplete records, a total of 345 incident cases were reported in original areas. Ler Per Her diagnosed 107 of 185 *P. falciparum* episodes of incident parasitaemia (58%) by microscopy. The annual incidence of *P. falciparum* in original areas declined from

**Table 1** Pilot malaria programme village characteristics recorded in bi-annual population censuses

| Village name | Households | Mean population | Range | Proportion tested during bi-annual screening (range) | Clinic with EDT† in village |
|---|---|---|---|---|---|
| Po Bu La Hta | 123 | 506 | 500–513 | (99.2–100%) | Yes |
| Ler Per Her | 89 | 389 | 356–428 | (84.5–94.7%) | Yes |
| Di Bu Noh | 126 | 706 | 647–751 | (98.7–100%) | Yes |
| Tee Ta Geh Ta | 60 | 267 | 240–291 | (98.3–100%) | Yes |
| Sub-Total 2003§ | 398 | 1868 | | 98.6% | |
| Klaw Gaw | 152 | 627 | 622–631 | (99.8–100%) | No‡ |
| New Ler Per Her | 114 | 613 | 596–630 | (87.2–93.8%) | No‡ |
| Mae Ngaw | 82 | 350 | 347–353 | (99.7–99.7%) | No‡ |
| Total 2004§ | 746 | 3457 | | 96.7% | |

†EDT: early diagnosis and treatment. Diagnoses were confirmed with the Paracheck Pf® device, except in Ler Per Her, which diagnosed 58% of incident cases by microscopy.
‡EDT available nearby for residents of Klaw Gaw and New Ler Per Her in Po Bu La Hta and Ler Per Her, respectively. EDT was unavailable in Mae Ngaw.
§Each year includes the 12-month period from February of that year to January of the subsequent year.

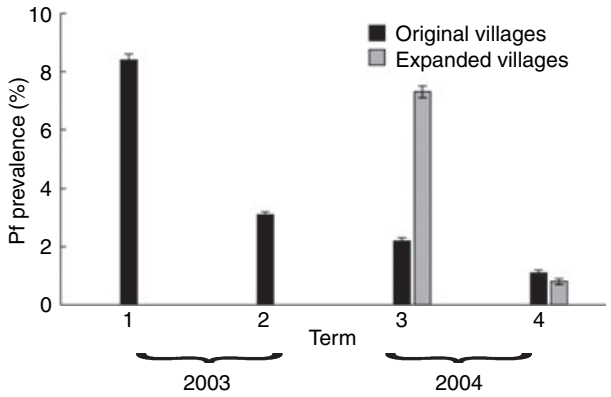


**Figure 2** *Plasmodium falciparum* prevalence in original and expanded pilot programme villages, by year and term. Error bars represent 95% confidence intervals (CI). Refer to text for relevant calculations.

232 [95% confidence interval (CI) 206–262] to 70 (95% CI 56–88) cases per thousand per year [incidence rate ratio (IRR) 0.30 (95% CI 0.24–0.39)].

### Age & sex

As reported elsewhere (Richards *et al.* 2007), baseline *P. falciparum* prevalence among children under 15 was higher in both 2003 (13.8%) and 2004 (9.3%) relative to adults (4.8% and 4.9%). However, prevalence was low among all age groups during programme implementation. The decline in incidence rates also was similar for each age group (data not shown). Prevalence and incidence of *P. falciparum* did not differ by sex for any age strata (data not shown).

### Net retention and use

Due to variability in the quality of house visit data during the first 6 months of the programme, only results from visits conducted in Terms 2–4 were analysed ($n$ = 12 627 visits). By the end of the second year, every household had received one or more LLITN. Retention was high, with 99.8% of households observed to have at least one LLITN (mean number of LLITNs per household = 1.7, village range 1.6–1.9). The proportion of all household members reportedly sleeping under the net the night prior to the visit improved from 0 to 89.7% (village range 76–96%); after excluding household members who had slept outside the village the proportion was 95.7%, (range 83–99%). The mean number of persons per net owned was 3.1 (village range 2.5–3.2), though the mean number of persons reportedly using each net was 2.7 (village range 2.4–2.9).

### Knowledge, attitudes and practices

Results of the knowledge, attitudes and practices (KAP) surveys are presented in Table 3. Knowledge of the cause and symptoms of malaria, the protective efficacy of ITNs and self-reported adherence to antimalarial drugs was low in most villages at baseline. Fourth term KAP surveys demonstrated a significantly higher proportion of correct answers for each question compared to baseline surveys.

**Table 2** Village *Plasmodium falciparum* prevalence and incidence, by term

| | Year | 2003¶ | | | | 2004¶ | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Term | 1 (Feb–July) | | 2 (Aug–Jan) | | 3 (Feb–July) | | 4 (Aug–Jan) | |
| Village | | *Pf*(+) | Rate | *Pf*(+) | Rate | *Pf*(+) | Rate | *Pf*(+) | Rate |
| Po Bu La Hta | Prevalence | 35 | 6.9% | 17 | 3.3% | 2 | 0.4% | 1 | 0.3% |
| | Incidence | 53 | 105 | 29 | 57 | 0 | 0 | 0 | 0 |
| Klaw Gaw† | Prevalence | | n/a | | | 37 | 6.0% | 0 | 0.0% |
| | Incidence | | n/a | | | 66 | 106 | 10 | 16 |
| Ler Per Her | Prevalence | 38 | 9.4% | 5 | 1.3% | 2 | 0.6% | 2 | 0.6% |
| | Incidence | 100 | 234 | 49 | 128 | 17 | 48 | 19 | 49 |
| Ler Per Her Expanded† | Prevalence | | n/a | | | 11 | 2.1% | 7 | 1.2% |
| | Incidence | | n/a | | | 6 | 10.1 | 2 | 3.2 |
| Di Bu Noh | Prevalence | 55 | 8.5% | 27 | 3.9% | 33 | 4.6% | 15 | 2.0% |
| | Incidence | | n/a | | | | n/a | | |
| Tee Ta Geh Hta | Prevalence | 23 | 9.6% | 7 | 3.0% | 3 | 1.1% | 2 | 0.7% |
| | Incidence | 5 | 21 | 32 | 133 | 27 | 111 | 14 | 48 |
| May Nga† | Prevalence | | n/a | | n/a | 61 | 17.6% | 6 | 1.7% |
| | Incidence | | n/a | | n/a | | | | |
| Total–Original Areas | | | | | | | | | |
| Prevalence | | 151 | 8.4% | 56 | 3.1% | 40 | 2.2% | 20 | 1.1% |
| Incidence‡ | | 158 | 135 | 110 | 97 | 44 | 39 | 33 | 31 |
| Total–Expanded Areas† | | | | | | | | | |
| Prevalence | | | | | | 109 | 7.3% | 13 | 0.8% |
| Incidence§ | | | | | | 74 | 60 | 7 | 10 |

Incidence = *Pf* parasitaemia episodes/1,000/6-month term. Prevalence surveys were completed over the course of several days in each village, and all villages conducted surveys within the first 90 days of each term (eg: Feb–April in terms 1 and 3; and Aug–Oct in terms 2 and 4) Surveys in the second year (2004) were conducted within 1 month of the date of the corresponding survey in the first year (2003) in each village.

†Expanded villages initiated the malaria pilot programme in 2004.

‡Incidence rates in original areas were calculated excluding Di Bu Noh due to incomplete data.

§Incidence rates in expanded areas were calculated excluding May Ngaw, where early diagnosis and treatment was unavailable.

¶Each year includes the 12-month period from February to January of the subsequent year.

## Discussion

This pilot programme demonstrates the feasibility of delivering cross-border malaria interventions among conflict-affected populations in eastern Burma, relying on a community-based organization. The programme achieved widespread acceptance and implementation of diagnostic, treatment, preventive and educational malaria control services. Cross-sectional *P. falciparum* prevalence (8.4–1.1%), as well as the annual number of episodes of parasitaemia declined dramatically (IRR 0.30).

This report provides empiric evidence that *P. falciparum* incidence in a conflict area in eastern Burma is higher (232 per thousand per year) than the incidence rates reported among Thais (48.2), foreign nationals (165.4) or displaced Karen (87.8) in western Thailand from 1999–2001 (Carrara *et al.* 2006) and among Burmese refugees living in nine Thai border camps (range 40–105) from 2003 to 2005 (Thailand Ministry of Public Health 2005).

In the second year of programme implementation, *P. falciparum* prevalence and incidence in the pilot population were comparable with estimates recorded during the Tak Malaria Initiative (TMI) from 2001 to 2002 (IR 61 per thousand per year). The TMI demonstrated the capacity of village health workers to implement early diagnosis and treatment (EDT) with artemisinin combination therapy (ACT) and reduce malaria transmission by one-third (Carrara *et al.* 2006). Our results suggest the possibility of extending the successes of the TMI approach to displaced populations in eastern Burma. The pilot programme achieved high coverage of ITNs, and net use exceeded contemporary (60%) and current (80%) Abuja targets (WHO 2005b).

### Limitations

This observational study was not a randomized trial, and a lack of concurrent data from non-intervention villages

**Table 3** Knowledge, attitudes and practices survey results at baseline and final term of programme implementation

| Question | Correct answers | | | |
|---|---|---|---|---|
| | Baseline ($n$ = 712) % | Final ($n$ = 690) % | Proportional change | $P$-value |
| 'What is the cause of malaria?' | 50.3% | 82.1% | 63.2% | <0.001 |
| 'What are the symptoms of malaria?' (must include fever) | 68.3% | 88.6% | 29.7% | <0.001 |
| 'If you use a mosquito net, can it protect you from malaria?' | 56.4% | 79.9% | 41.7% | <0.001 |
| 'Does insecticide treatment of nets improve protection against malaria?' | 66.4% | 91.0% | 37.0% | <0.001 |
| The last time you took pills for malaria, did you take all of the pills as the medic instructed? | 79.5% | 94.6% | 19.0% | <0.001 |
| Where did you go FIRST, the last time you had malaria? | | | | |
| Medic/clinic | 78.9% | 84.0% | 6.5% | 0.01 |
| Pharmacy | 8.6% | 5.8% | −32.6% | |
| Other | 10.4% | 8.1% | −22.1% | |

'Baseline Survey' = Term 1 for original villages and Term 3 for expanded villages.
'Final Term' = Term 4 (except Tee Thaw Geh Hta = Term 3).

further limits causal inference. It is unlikely, however, that secular trends account for the observed decline in prevalence and incidence. First, areas implementing the programme repeatedly recorded lower prevalence rates than other villages prior to initiating interventions. In Term 3, new villages recorded higher baseline prevalence than original villages (Figure 2). This observation is similarly supported in a report of 1588 RDTs performed by KDHW in 2004 as part of a cluster survey to estimate mortality rates in the entire target population of 96 888. *P. falciparum* prevalence in areas not participating in the programme was substantially higher (11.8%) during a period concurrent with Term 4 when original pilot programme areas recorded a prevalence of 1.1%. (Richards *et al.* 2007). Prevalence in pilot programme areas remained lower than baseline prevalence in 14 areas into which this pilot programme expanded in 2005. In these expanded populations, baseline *P. falciparum* prevalence among 8052 IDPs was higher (10.5%) than among a sample of heads of household from pilot programme areas that initiated the programme in 2003–2004 (eight of 737 = 1.1%). A secular trend is unlikely to explain our findings as a similar decline in clinical malaria cases was not recorded in non-intervention clinics. Although precise population records are not available to calculate incidence rates, annual total case counts in non-intervention clinics serving a population of approximately 85 000 were similar for each year from 2002 to 2004 (KDHW, unpublished data).

Screenings in original areas were not conducted during identical months of 2003 and 2004, which may have introduced bias in our prevalence estimates due to seasonal variation in malaria transmission. However, the modest delay of screening in 2004, which was limited to 1 month in three villages during the dry season in Term 3, is unlikely to explain our observations, given that the prevalence recorded concurrently in new programme villages (7.3%) was higher than in active programme villages (2.2%). The dry season delay also would not explain the lower prevalence recorded during the rainy season in both 2003 and 2004, when malaria prevalence in this region typically increases (Richards *et al.* 2007).

A further limitation of this study is that the more accurately measured outcome was prevalence and not the clinically more relevant incidence. Complete incident case records in Di Bu Noh were available only from the period October to December of each year. In those 3 months, the lower number of *P. falciparum* cases in 2004 ($n$ = 41) than in 2003 ($n$ = 111) is consistent with a reduction of *P. falciparum* incidence in Di Bu Noh as well.

Passive surveillance at clinics may have led to an underestimation of the true incidence of parasitaemia in this population, but the proportion of symptomatic cases undiagnosed was likely reduced by active referral and by frequent reinforcement of care-seeking messages. Although we cannot rule out the possibility that some villagers sought treatment across the border in Thailand, this practice almost certainly was limited to the two villages immediately across the border, and it is unlikely that this practice would become more common during a period of improved access to treatment closer to home, and when malaria-related knowledge increased.

Security concerns limited the type and quantity of data collected (e.g. use of personal identifiers was proscribed) and we did not directly measure several factors related to malaria transmission, including migration, 'forest related

activity', low drug quality, or cure rates. Adherence was directly observed, but inconsistencies in data collection during the first year (quality control revealed that some health workers initially recorded what patients were prescribed instead of what they were observed to receive) precluded the presentation of quantitative results. Each of these factors would have compromised our ability to demonstrate a decline in malaria prevalence.

This report suffers from a lack of quality control of the RDT results by comparison to expert microscopy or polymerase chain reaction; and the use of an RDT may have limited the ability to detect asymptomatic infection and/or low level parasitaemia (Guthmann *et al.* 2002; Moody 2002; Murray *et al.* 2003). However, Paracheck-Pf® has demonstrated impressive sensitivity and specificity under field conditions during asymptomatic screening of children in India (sensitivity/specificity 94.4 & 89.0% respectively) (Singh *et al.* 2002), and in Tanzanian villages with either high (40.1%), low (4.3%), or very low (1.9%) *P. falciparum* prevalence (sensitivity 83.6, 100%, n/a; specificity 94.1%, 99.5%, 98.4% respectively) (Mboera *et al.* 2006; Shekalaghe *et al.* 2007). Because Paracheck-Pf® detects only a *P. falciparum* related antigen, we are unable to evaluate the impact on the prevalence of other plasmodium species. Paracheck-Pf® was preferred because other RDTs capable of detecting non-*falciparum* parasitaemia were not recommended by local consensus guidelines for use in the programme area, and lacked evidence supporting their use during population screening. Furthermore, the alternative diagnostic strategy in remote areas – field microscopy with a natural light source – has shown unacceptably poor sensitivity (as low as 10%) for asymptomatic *P. falciparum* parasitaemia compared to expert microscopy in western Thailand (Coleman *et al.* 2002).

The accuracy of RDTs may be compromised by high-temperatures or prolonged storage under field conditions (Mboera *et al.* 2006), but storage in thatched huts likely minimized extreme temperatures in our case, and fresh RDTs were supplied every 6 months to reduce storage time. Poor RDT sensitivity is unlikely to explain our findings because non-programme areas continued to record high proportions of positive RDTs.

We conducted this pilot programme to evaluate the feasibility of delivering an integrated package of malaria control interventions in a novel setting; our data do not permit an evaluation of the relative contribution of each intervention, or the potential impact of less intensive strategies. Similar programmes incorporating population screenings, EDT and ITNs support their combined effectiveness (Hung *et al.* 2002; Carrara *et al.* 2006; Sochantha *et al.* 2006; Ngo Duc *et al.* 2009); however, evidence from randomized controlled trials is lacking to support an additional benefit of LLITNs in the setting of EDT with ACTs in southeast Asia. The pilot programme included the remote village Mae Ngaw to explore the impact of LLITNs alone, but in early 2005 the State Peace and Development Council attacked the village, interrupting programme activities and forcing the entire population to flee.

Although the attack prevented an assessment of the LLITN-only strategy, the experience provided an opportunity to focus on increasingly remote and/or repeatedly displaced populations. As we describe elsewhere (Lee *et al.* 2009), since 2005 our group has trained nearly 100 villagers without prior malaria-related experience to provide EDT. This emphasis on village health workers parallels international trends toward increasingly local or 'home-based' management of malaria and facilitates access to remote populations. The Karen programme now reaches more than 40 000 IDPs and has served as a model for similar community-based programmes along Burma's borders with China and India. Ongoing evaluation of these programmes will determine whether the initial successes of this pilot programme can be replicated and sustained over time.

## Conclusions

This pilot programme demonstrates the feasibility of an integrated cross-border malaria control programme organized by and for internally displaced persons in an area of active conflict. The dramatic reduction in *P. falciparum* prevalence and incidence recorded in the first 2 years suggests that it may be possible to reduce the reservoir of malaria in eastern Burma, with implications for malaria control in the greater Mekong region. International support for malaria control along Burma's otherwise inaccessible borders should include the participation of IDPs and vulnerable communities that currently receive minimal services despite suffering a high burden of disease.

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**Corresponding Author** **Adam K. Richards**, Department of General Internal Medicine and Health Services Research, University of California at Los Angeles, 911 Broxton Ave., Los Angeles, CA, USA 90024. Tel.: 01 310 794 2904; Fax: 01 310 794 3288; E-mail: arichar2@jhmi.edu