Malaria control using permethrin applied to tents of nomadic Afghan refugees in northern Pakistan

M.J. Bouma,1 S.D. Parvez,2 R. Nesbit,3 & A.M.F. Winkler1

Malaria control among nomadic populations has, in the past, posed serious logistic difficulties. Presented in this article are the results of a pilot study in which permethrin was sprayed on the tents of over 26,000 nomadic Afghan refugees in an area of Pakistan where seasonal malaria outbreaks occur. In this area Anopheles culicifacies and A. stephensi are the malaria vectors. Population surveys in the year of the study, before and at the end of the transmission season, showed that the increase in the Plasmodium falciparum prevalence among the Afghan nomads was on average significantly less (increase from 6.4% to 15.3%) than that among the resident Pakistani population (from 3.2% to 45.6%). Surveys at the end of the transmission season among primary schoolchildren the year before and the year of the permethrin trial showed that the P. falciparum prevalence among nomadic children decreased significantly (from 46.9% to 16.3%), whereas an increase was observed among the local Pakistani children. The results show that spraying tents with permethrin was a safe and culturally acceptable intervention for the Afghan refugees and that the findings warrant further investigation.

Introduction

Migration and nomadic movement have been major obstacles in the control of malaria, as described by Motabar & Behbani for nomads living in tents in the Islamic Republic of Iran. Nomadism is still a prevalent way of life in many parts of Africa and Asia, and has been associated with the resurgence of malaria in certain areas of the Middle East (1) and the spread of chloroquine-resistant strains of Plasmodium falciparum in India (A. Kondrachin, personal communication, 1992) and other south-east Asian countries (2). Dupree has estimated that Afghanistan has 2 million nomadic or semi-nomadic inhabitants (3). Between 30,000 and 60,000 of these have lived in Pakistan since 1979 and make their seasonal trek to the cooler mountainous areas of South Waziristan, where they live in tents during the warmer months (May–September). Some use their traditional tents, but most live in tents provided by the Office of the United Nations High Commissioner for Refugees (UNHCR). Among the Afghan refugees in Pakistan, Suleman has reported that malaria is a major health problem (4); and Afghan refugees with a nomadic lifestyle showed a particularly high incidence of falciparum malaria in the late 1980s.

The application of insecticides to tents has been carried out in the past; for example, Motabar has reported the experimental use of DDT, dieldrin and hexachlorocyclohexane on nomads’ tents in the Islamic Republic of Iran’s Malaria Eradication Programme (5). The short residual effect of these insecticides when applied to canvas, particularly to movable tents, limited their impact. The introduction of pyrethroids with a long residual action, and which are particularly suitable for application to textile fabrics, might overcome these limitations (6). Recently in a joint Pakistan/U.S. Army pilot programme, Qureshi et al. reported a method of applying permethrin to tents (7).

The level of malaria among the migrant Afghan population in the North-West Frontier Province (NWFP) of Pakistan demanded urgent action. Accordingly, a pilot programme was set up to spray approximately 5600 tents with permethrin, involving over 26,000 nomadic refugees. This article reports the results of the baseline studies, the logistics of the spraying operation, which have not previously been attempted on this scale with permethrin, and the impact.
Materials and methods

Trial area and population

South Waziristan Agency is a politically unstable, tribal area of Pakistan, bordering Afghanistan, whose capital is Wana (32° 18'N, 69° 35'E). The trial area consists of a wide valley (19 km × 13 km) on a plain at an altitude of 1300–1750 m (Fig. 1), west of the Mahsud Highlands, one of the southern ridges of the Hindu Kush. The summers on the plain are cool and the winters cold with sub-zero temperatures. Annual precipitation is approximately 300 mm, with March, February, April, and July (in decreasing order) having the most rainfall. The plain is intersected by many river beds, which become torrents during the rainy season. These and the perennial water bodies that persist in the dry season feed a system of channels used for crop irrigation. The main river in this well-watered plain is shown on the map (Fig. 1). The population of Wana and surrounding settlements consists of Pakistani Pathans, and an estimated 30000 resident Afghan refugees. Another 25000–30000 semi-nomadic Afghan refugees live in the area between May and September, spending the rest of the year in lower parts of NWFP and the Punjab. Table 1 shows the distribution of the local and (nomadic) refugee population in the area. In the NWFP, particularly at higher altitudes, P. vivax is the predominant malaria parasite (8). South Waziristan is exceptional in that, despite its altitude, more cases of P. falciparum than of P. vivax malaria have been reported by UNHCR in recent years, with the microscopic diagnosis being verified by Médecins sans Frontières-Holland.

For the Pakistani Pathans and resident Afghan refugees, an annual malathion spraying campaign (50% water soluble powder, delivery dose 2g/m2) is carried out in July and August, parallel to the spraying operations in the other districts in NWFP, where transmission increases after the July–August monsoon rains. For the nomadic refugees no vector control measures had been undertaken prior to the present study.

Entomology

In September 1989, prior to the trial in 1990, entomological baseline data were collected. Morning captures of indoor resting Anopheline spp. were made in the tents and houses of the refugees and local population. Local vector species were identified and used for insecticide susceptibility testing, with WHO-impregnated papers (permethrin (0.25%), malathion (5%), and DDT (4%)) and a WHO-recommended methodology (9). Corrections for mortality in the control sample were made using Abbott’s formula:

Table 1: Estimated population in Wana and surrounding settlements and total/sprayed tents, 1990

<table>
<thead>
<tr>
<th>No. of residents:</th>
<th>No. of Afghan nomads*</th>
<th>No. of tents:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total</td>
</tr>
<tr>
<td>Pakistani</td>
<td>Afghan</td>
<td></td>
</tr>
<tr>
<td>Wana</td>
<td>50000</td>
<td>—</td>
</tr>
<tr>
<td>Pir Bagh</td>
<td>7000</td>
<td>5000</td>
</tr>
<tr>
<td>Wadja Ghora</td>
<td>—</td>
<td>4800</td>
</tr>
<tr>
<td>Zari Noor</td>
<td>—</td>
<td>15000</td>
</tr>
<tr>
<td>Deja Ghundi</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Azam Warsak</td>
<td>11000</td>
<td>10000</td>
</tr>
</tbody>
</table>

* For the period May – September.
* Figures in parentheses are the % of tents that were sprayed.
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\[
\text{% mortality} - \text{% control mortality} \times 100
\]

An entomological team from the National Institute for Malaria Research and Training (NIMRT) spent one night observing the feeding behaviour of local mosquitoes in Wadja Ghora (Fig. 1). The resting habits of a vector determine to a large extent whether it will make contact with the wall of a dwelling, and thus be exposed to a residual insecticide. Pakistan's principal malaria vectors, *A. culicifacies* and *A. stephenii*, are strongly endophilic\(^b\) and this may account for the success of previous spraying operations, such as the malathion campaigns described by de Zulueta et al. (10). We nevertheless investigated the endophilic tendency of the local vectors in the tents used by the refugees. This was carried out using morning hand collections of vector species from tents as well as an exit window trap, which was installed for two nights at one end of a refugee tent in Wadja Ghora.

**Materials and spraying methods**

A 25% emulsifiable concentrate (EC) of permethrin (Imperator ICI, Karachi, Pakistan, cis/trans-ratio = 40/60) was procured by UNHCR. A 0.5% (v/v) emulsion was obtained by mixing 152 ml of the concentrate with 7.56 l (2 gallons) of water. Most of the refugees in the area use fly-sheeted, ridge-pole tents provided by UNHCR. These tents (4-m long, 2.1-m high, and 3.5-m wide) consist of a cotton canvas outer flysheet (480 g/m\(^2\)) and an inner tent made from two identical cotton sheets (390 g/m\(^2\) combined). The surface area of the inner tent is 30 m\(^2\). The permethrin emulsion was applied, using hand-compressed sprayers, from the inside to the inner tent to the point of run-off, following the method described by Qureshi et al. (7), to give target doses of 0.5 g active ingredient (a.i.) per m\(^2\). For the campaign, new sprayers (Hudson, Chicago, IL, USA) were supplied by UNHCR. Additional equipment included an unbreakable cylinder to measure accurately the amount of emulsifiable concentrate and a funnel to separate sediments and floating parts from the water.

Spraying was carried out by local Afghan Refugee Health Programme personnel in squads consisting of two, occasionally three spraymen, and a mixer. The mixer also had the task of marking the sprayed tents with red paint; this mark had to be visible from a long distance, allowing monitoring of progress and coverage. Most of the spraying staff had been involved previously in malaria spraying campaigns using malathion but were given additional training appropriate to the pilot study. Particular attention was paid to the mixing of the permethrin concentrate, the spraying technique, and the importance of covering the walls of the tent near the ground, where most vectors rested. The supervisors, each of whom was in charge of two squads, received a separate day of training. Their responsibilities included technical supervision, record-keeping, and informing and instructing the population in advance of the spraying operations. The refugees were requested to remove foodstuffs and cooking utensils from the tent interiors and not to replace them until at least 4 hours after completion of the spraying, and to free the walls of the tent from bedding, blankets, and clothes. They were not instructed to remove these items from the tents, in view of the known safety of permethrin (6) and the possible desirable effect on ectoparasites, e.g., lice, resulting from unintentional deposition of the permethrin emulsion on the interior of the tent. In four locations close to Wana town (see Fig. 1), 5594 tents were sprayed between 23 June and 14 July 1990. Tents in Wadja Ghora were sprayed on 23 and 24 June, parts of Deja Ghundi and Pir Bagh on 25–29 June, and the remainder of Pir Bagh, Deja Ghundi and Azam Warsak on 7–14 July. According to information provided by the heads of the families during the spraying operations, the tents that were sprayed housed 26119 inhabitants. The proportions of tents treated in the nomad settlements are shown in Table 1.

**Evaluation of the campaign: indicators for malaria**

Initially it was intended to divide the tents into an experimental group (for permethrin spraying) and a control group; however, this would have been ethically and politically not acceptable. In the absence of a control group, random mass surveys were carried out to compare the malaria prevalence in nomadic refugees (permethrin trial) and the local population (annual malathion spraying campaign). The surveys were conducted before and towards the end of the transmission season. Prevalence surveys among local and refugee schoolchildren were also carried out the year before and the year following the permethrin spraying to provide malaria data for two successive years in both population groups. Only *P. falciparum* infections were used as an indicator of transmission, since *P. vivax* infections may have been due to relapses of infections contracted in previous years. For the population surveys, an age group analysis was

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carried out to correct the prevalence data for age, using direct standardization, as described by Kirkwood (11). Significance tests between proportions were used with continuity correction. Data from the (seasonal) health units were used to calculate the *P. falciparum* infection rate (proportion of slides taken based on clinical indications that were positive for this species).

**Data from health services.** Wana has one district hospital, with an outpatient department. The main task of the microscopist in the hospital is the diagnosis of malaria. Microscopical diagnosis and treatment are also provided by three private doctors in Wana. In addition, there is a small Arabic agency hospital in Azam Warsak. The main hospital in Wana keeps records of the microscopic diagnosis, but no clinical records. The hospital is also accessible to Afghan refugees, but the basic health units (BHU) run by UNHCR and its local counterpart provide diagnostic and treatment facilities free of charge. These facilities can also be used by the (poorer) local population. For the seasonal refugees, extra health units are established between May and October in Wadja Ghora and Deja Ghundi, in addition to the permanent BHUs in Pir Bagh, Zari Noor, and Azam Warsak (Fig. 1). Malaria registers are kept in the health units and field laboratory. This patchwork of medical services, available to both refugees and the local population, makes analysis of the available data difficult. Reduced diagnostic and treatment services in the refugee programme between July and October 1990 as a result of a strike, further complicated the interpretation of data.

**Prevalence surveys.** In 1990, when the permethrin trial was carried out, blood smears (thick smears and thin films) were collected in the weeks following the arrival of the nomads (May) at the start of the malaria transmission season and in the weeks before their departure (mid-September) towards the end of the season. In two locations where the tents of the refugee population were sprayed, Wadja Ghora (*n* = 191 in May and *n* = 231 in September), and Pir Bagh (*n* = 203, and *n* = 211, resp.), smears from all the family members living in tent clusters were obtained. Selection of these clusters was at random (12). Blood smears from the local population were collected from all the inhabitants of clusters of randomly selected houses around Azam Warsak (Fig. 1), an agricultural rural area (*n* = 150 in May and *n* = 195 in September). The surveys of nomads and the local population were conducted simultaneously.

**School surveys.** In September 1989 thick smears and thin blood films were collected from Afghan refugee primary schoolchildren (aged 4–15 years) in Wadja Ghora (*n* = 41) and from local schoolchildren in Azam Warsak (*n* = 68). Half of the classes in the local school in Azam Warsak had already left the area when the survey was carried out in 1989. Surveys were repeated in the same week of September 1990 in the same Afghan (*n* = 63) and local (*n* = 176) schools. The Afghan schoolchildren surveyed were all from families whose tents were sprayed with permethrin in 1990.

**Microscopical diagnosis.** Thick smears and thin blood films were Giemsa stained and at least 100 high-powered fields from the thick smear were examined. From positive slides, species diagnosis was confirmed on the thin film. Staining and microscopy were carried out in the field laboratory of the Afghan refugee programme in Wana, and individuals with positive slides were subsequently treated, whether they were symptomatic or not. All slides were transported to the central malaria reference laboratory in Peshawar and rechecked for the accuracy of the diagnosis.

### Results

#### Entomological findings

Entomological baseline studies in September 1989, the year before the permethrin trial, showed that *A. culicifacies* and *A. stephensi*, both of which are malaria vector species in Pakistan, were the only anophelines caught in the trial area. In the tents of refugees both these species were found resting mainly on the interior surface of the inner tent, particularly against the lower walls close to the floor, often behind stacked bedding material. The female mosquitoes found resting in tents were in various stages, from blood-fed to gravid. The captures in an exit window trap installed in a tent for two nights yielded only unfed, gravid and male specimens (3, 2, and 4, resp., for *A. culicifacies*; and 2, 1, and 4, resp., for *A. stephensi*) suggest that these vectors find suitable resting places inside tents after feeding.

Susceptibility tests (Table 2) showed that permethrin was the most effective insecticide against both vector species. Malathion was less effective, and DDT, to which only *A. stephensi* were exposed, the least. Cross-resistance between DDT and permethrin in *A. stephensi*, which has been reported in laboratory studies in Pakistan by Ömer et al. (13) is not apparent from our results.
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Table 2: Results of the insecticide susceptibility testing for Anopheles culicifacies and A. stephensi, exposed to permethrin, DDT and malathion

<table>
<thead>
<tr>
<th>Test paper</th>
<th>A. culicifacies</th>
<th>A. stephensi</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. exposed</td>
<td>No. killed</td>
</tr>
<tr>
<td>Permethrin (0.25%)</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>DDT (4%)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Malathion (5%)</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>Control</td>
<td>10</td>
<td>1</td>
</tr>
</tbody>
</table>

* Corrected for mortality among controls using Abbott's formula.

Spraying operations

A total of 437 litres of permethrin 25% EC was sprayed on 5594 tents. Based on a surface area of 30m² for the UNHCR tents (approximately 95% of all those in the area), this corresponds to a concentration of 0.65g a.i. per m² of tent surface, slightly higher than the targeted 0.5g a.i. per m². One tent in the trial area was employed periodically to assess the residual effect of permethrin using bioassays and gas chromatography. A sample collected from the inner tent one day after spraying had a concentration of 0.474 g.a.i./m², slightly below the target dose. In the fly-sheeted tents, used by most of the nomads, the residue remained effective for over 6 months (14).

Logistically, few problems were encountered. The refugees provided the water for making the permethrin emulsion. Spraying the 5594 tents required a total of 263 man-days — equivalent to 21.3 tents per person per day — taking into account only those directly involved in spraying (spraymen and mixers) but not the malaria supervisor. A standard squad consisting of two spraymen and a mixer sprayed, on average, 63.9 tents per day. Excluding the support of the mixer, the spraying time per tent, including transport to the site and local arrangements, was 11.3 minutes, based on a 6-hour working day.

No adverse effects from the permethrin spraying operations were reported. The absence of toxic side-effects and the immediate impact on flies, combined with the absence of smell or colour of the permethrin emulsion, resulted in a high level of cooperation from the nomads. A total of 266 tents (4.5%) remained unsprayed. This was mainly due to the absence of the inhabitants or of the male head of the family. In the latter circumstances, according to the cultural custom, the women refused entry.

Effect on malaria

Fig. 2 shows the seasonal increase (age-corrected) in the prevalence of P. falciparum for all the locations surveyed. In May, early in the season, the prevalence was lowest among the local population. The increase in prevalence from May to September was most striking among the local Pakistani population in Azam Warsak (from 3.2% to 45.6%; significant, P < 0.001). In Wadja Ghora, the nomad locality first sprayed with permethrin, the seasonal increase was only marginal (not significant, P > 0.05) from 4.7% to 5.8%. In Pir Bagh, where permethrin spraying operations were completed on 14 July 1990, the increase to 24.7% in September was significant (P < 0.001), albeit significantly less so (P < 0.001) than in the local population in Azam Warsak. Combination of the data for both nomad locations indicated that the seasonal increase (from 6.4% to 15.4%) was significantly less (P < 0.001) than that among the local population.

Fig. 3 shows the prevalence of P. falciparum in September according to the age group of the nomads (data for both locations combined) and the local population. The prevalence increased among 0-15-year-olds and, following a decline, remained unchanged among the older population. This pattern

![Graph showing seasonal increase in prevalence of P. falciparum](image-url)
occurred in both population groups, despite an overall lower prevalence among the nomadic refugees.

Prevalence surveys of schoolchildren provided information on the malaria prevalence in a Pakistani and an Afghan nomad location in September 1989 and in September 1990, after the permethrin spraying campaign for nomads in June and July 1990 (Table 3). The P. falciparum prevalence among schoolchildren in Wadja Ghora, the Afghan nomad site where the malaria prevalence surveys did not show a significant seasonal increase, was high in the year before the permethrin intervention (46.9%), and decreased significantly to 16.3% ($P < 0.002$) following the spraying of their tents. In comparison, schoolchildren from the local population in Azam Warsak (western side of the Wana plain) exhibited the opposite trend, with a significant ($P < 0.001$) increase in malaria prevalence from 11.6% in 1989 to 40.7% in 1990. Less than 3% of schoolchildren in either population group claimed to have been outside the Wana plain in the 3 months preceding the September survey, which supports the initial assumption that malaria transmission was occurring in the area.

Table 3: Results of malaria prevalence surveys in primary schools in September 1989 and after the permethrin spraying campaign of nomadic refugees' tents in September 1990

<table>
<thead>
<tr>
<th>September 1989:</th>
<th></th>
<th>September 1990:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$n$</td>
<td>No. positive for</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P. falciparum malaria</td>
</tr>
<tr>
<td>Nomads (Wadja Ghora)</td>
<td>41</td>
<td>18 (43.9)$^a$</td>
</tr>
<tr>
<td>Local population (Azam Warsak)</td>
<td>68</td>
<td>8 (11.8)</td>
</tr>
</tbody>
</table>

$^a$ Figures in parentheses are percentages.
Fig. 5. Number of cases of *Plasmodium falciparum* diagnosed in Wana hospital in 1990 (trial year) and in early 1991, by month, in the local and refugee populations.

populations, with a maximum in September, i.e., after the peak of *P. vivax* in July (not shown). The seasonal increase in *P. falciparum* cases began in May, much earlier than in the other districts in NWFP. The cases of *P. falciparum* among the Afghan refugees after September, i.e., after departure of the nomads to their winter quarters, show the considerable contribution of the resident, non-migrant refugees to these monthly malaria data.

**Discussion**

The study reported here was a response to the deteriorating malaria situation among nomadic Afghan refugees in a remote and politically unstable area in the North-West Frontier Province of Pakistan. The presence of malaria vectors and malaria data from the resident Pakistani population and Afghan refugees suggested that transmission was taking place in this high-altitude area. Entomological confirmation of this and collection of more extensive baseline data were not attempted at the time, because of the urgency for remedial measures. Knowledge of the endophilic character of Pakistan's vector species, *A. culicifacies* and *A. stephensi* (10), which were both present in the area, and our observations that these vectors indeed used nomads' tents as resting places, suggested that the application of residual insecticide was likely to reduce malaria transmission, as reported for other insecticides in Pakistan (10). The decision to use permethrin was based on the finding that the local vectors were more sensitive to it than to any other insecticide tested, and because other workers have reported that it is particularly suitable for treating textile fabrics (6).

The spraying activities were operationally successful, requiring only minor adaptations by staff previously involved in other spraying campaigns. No negative side-effects were observed among the spraymen, and the properties of permethrin meant that it was well received by the target population. An effective permethrin residue, which was determined in an experimental tent, persisted for at least 6 months, much longer than that of the insecticides previously used for the control of malaria in nomadic populations. However, in single sheet tents, used by a few nomads in the trial area, the residual effect was lower (14) and may have marginally reduced the impact of the spraying operations.

The political instability in the area and the reduced health facilities in the Afghan Health Programme during the trial restricted monitoring the effects of permethrin spraying on the vector population and on disease. Disease data from the local hospital and health units of the refugee programme must be interpreted with caution. The fall in the number of *P. falciparum* cases diagnosed in the refugee programme probably resulted from the reduction in services during the trial. This is likely to have increased the hospital attendance of refugees, where more cases of *P. falciparum* were diagnosed in the year of the trial than in the previous year. However, non-migrating resident refugees also contributed to this figure, as illustrated by the number of cases reported after September, when the nomadic refugees had left. The striking increase in cases of *P. falciparum* malaria reported by the hospital among the local population and the increased prevalence of this species of malaria parasite in local schoolchildren suggest that there was an increase in malaria transmission in the local population in 1990. The decrease in the prevalence of *P. falciparum* among Afghan schoolchildren after the permethrin spraying and the significantly lower seasonal increase in cases of malaria among the nomadic populations compared with the local community suggest that the permethrin spraying had a protective effect. Alternatively the lower prevalence among the nomadic refugees could have arisen because in the past they may have had a greater exposure to malaria and thus a higher level of protective immunity. However, the age distribution of the malaria prevalence in both groups, which also reflects previous exposure, is very similar. Direct comparison between local and refugee populations may further have been biased by unnoticed differences in vector populations, sleeping conditions, and the presence of animals. It is not likely that the lower prevalence of malaria among the nomads arose because they received better treatment. The reduced health services that were available for refugees during the trial probably resulted in some patients attending private clinics and the hospital in Wana. The timing of the spraying operations may have been an important factor that accounted...
for the results of this study. The prevalence of *P. falciparum* malaria among the nomads whose tents were sprayed with permethrin in June had not increased by the end of the malaria season, and the highest prevalence was found among the local population who received a late malathion spraying in July and August (to which the vectors were sufficiently susceptible in the study area). Since cases of *P. falciparum* malaria start to increase in May, the area that was sprayed first is likely to have benefited most from the spraying, and better results could have been expected had the permethrin campaign started a month earlier.

Ethical considerations prevailed over the choice of the experimental design for this study. Although the evidence for the impact of the spraying operations is circumstantial rather than conclusive, the results of this pilot programme were sufficient to support the continuation of permethrin spraying operations for nomadic refugees in the North-West Frontier Province. The repellent and mortality effects of permethrin-sprayed tents on the vectors need to be studied further. Schreck has reported a reduction in biting by *A. aegypti* in a permethrin-treated tent ([5]), and entomological follow-up studies in Pakistan are being carried out (M. Rowland & S. Hewitt, personal communication, 1994). The use of pyrethroids to control malaria and other vector-borne diseases among nomadic populations living in tents warrants further research. International agencies that use tents for their aid workers in emergencies, and provide tents as temporary shelter for displaced populations, may also benefit from the vector control method we have described.

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**Résumé**

Lutte antipaludique par application de perméthrine sur les tentes de réfugiés afghans nomades dans le nord du Pakistan

La lutte antipaludique chez les populations nomades a dans le passé posé de graves problèmes logistiques. Cet article présente les résultats d’une étude pilote dans laquelle la perméthrine a été appliquée par pulvérisation sur les tentes de plus de 26 000 réfugiés afghans nomades dans une région du Pakistan où le paludisme sévissait sous forme de flambées saisonnières. Dans cette région, les vecteurs du paludisme sont Anopheles culicifacies et A. stephensi. Des enquêtes en population réalisées l’année de l’étude avant la saison de transmission et à la fin de celle-ci ont montré que l’augmentation de la prévalence des infections à *Plasmodium falciparum* chez les nomades afghans était en moyenne significativement plus faible (passage de 6,4% à 15,3%) que chez les résidents pakistanais (passage de 3,2% à 45,6%). Les enquêtes réalisées à la fin de la saison de transmission chez les écoliers du primaire l’année précédente et l’année de l’essai ont montré que la prévalence des infections à *P. falciparum* chez les enfants nomades avait diminué de façon significative (de 46,9% à 16,3%), tandis qu’une augmentation avait été observée chez les enfants pakistanais de la région. Ces résultats montrent que la pulvérisation de perméthrine dans les tentes est une intervention sans danger et culturellement acceptable pour les réfugiés afghans et que les travaux dans cette voie doivent être poursuivis.

**References**


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