RESEARCH NOTE

LAMBDACYHALOTHRIN IMPREGNATED BEDNETS CONTROL MALARIA IN SABAH, MALAYSIA

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Recently, the availability of synthetic pyrethroids in their improved insecticidal form has made it possible for medical entomologists and malariologists to conduct field trials with impregnated bednets for malaria control. Epidemiological and entomological studies in Tanzania and China suggest that pyrethroid-impregnated bednets (IBNs) are more effective than DDT spraying (Curtis *et al*, 1990; Njunwa *et al*, 1991; Lu, 1992). In substantiating this claim we present evidence of a field trial in Sabah, Malaysia.

The study was undertaken in Kudat, a rural district in Sabah, which is 220 km north of the equator and approximately 136 km northeast of the state capital, Kota Kinabalu. The average population density is roughly 30/km^2, and 75% of the people are Rungus. Most Rungus are subsistence farmers who practise slash and burn swidden agriculture with hill rice as the primary crop supplemented by cassava, maize, vegetables and fruits. In 1988 the reported annual parasite incidence(API) was 102.4 per 1,000 (85.4% *Plasmodium falciparum*; 14.5% *P. vivax*), with 65% of the population living in areas of active malaria transmission. The rainy season extends from October to January with peak malaria incidence at its and in the month after, although there is year-round transmission. Routine anti-malaria operations in the district consisted of a twice-yearly house spraying program using DDT wettable powder in 109 villages supplemented by mass drug administration when the parasite incidence rate exceeded 10 per 1,000, parasitological diagnosis of fever cases and appropriate treatment through government-administered health facilities. Currently, a functional and sustainable community participation health program ("Sukarelawan Penjagaan Kesihatan Primer" or SPKP) covering a population of 10,341 among 36 villages is providing malaria surveillance and presumptive chemotherapy through a network of village health volunteers or VHVs (Hii *et al*, 1992). Following the successful implementation of SPKP in Kudat, the national Vector-Borne Diseases Control Program adopted and supervised the impregnation of polyethylene mosquito nets with lambdacyhalothrin (in the form of 'Icon' 25% emulsifiable concentrate) in eleven villages (population: 2,183) selected from the 36 SPKP villages. The target dosage rate was 25 mg ai/m^2. The impregnation was carried out by the villagers themselves under the instruction and supervision of malaria technicians and, thus, the task of treating 911 nets was accomplished within 14 days in October 1990 and October 1991. At the same time indoor residual spraying with DDT 75% wettable powder was carried out in another eleven villages (population: 3,413) selected from the 36 SPKP villages. The target dosage applied was 2 g DDT ai/m^2, and sprayings were applied twice in these villages in January-March 1990 (first round) and July-September 1990 (second round). Due to DDT shortage in 1991, only one village (Pata) was sprayed twice (March and August 1991) and in ten villages once in July-September 1991. One spray round (March 1992) was applied in 2 villages and 8 villages received two spray rounds in March, July and November-December 1992. Spraying coverage reached as high as 94.1% of 801 houses including partially sprayed structures in 1990. More than 95% of nets were treated in 1990 and 1991 and acceptability of nets was high. Side effects were running eyes and mild skin sensations on the hands and running eyes of those who dipped nets in a plastic basin, even though rubber gloves were worm. Villagers who used lambdacyhalothrin

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Table 1

Malaria incidence (per 1,000) in Bednet and DDT villages before and after intervention. year 1: Nov 1989 to Oct 1990; Year 2: Nov 1990 to Oct 1991; Year 3: Nov 1991 to Oct 1992.

Bednet villages	Year 1	Year 2	Year 3	DDT villages	Year 1	Year 2	Year 3
Timug	521.7	10.2	26.9	Sampir	85.2	49.1[b]	79.3
Pituru	400.0	9.4	5.3	Nangka	44.4	30.0[b]	7.4
Onduan	331.3	28.6	43.9	Pinawantai	255.2	17.1[b]	3.7[c]
Teringai	286.7	186.9	81.8	Kirangawan	147.3	97.4[b]	160.7
Malamam	280.5	50.2	10.0	Rondomon	156.9	51.3[b]	286.6[a]
Tagamunal Darat	270.6	29.1	13.2	Pinurat	198.8	90.9[b]	41.4[c]
Kaidangan	244.7	33.0	11.0	Marabahai	253.5	59.1[b]	66.7
Paradason	193.5	52.1	40.8	Lokoton	105.1	54.1[b]	17.6
Dumpiring	161.1	19.4	4.9	Ronggu	218.2	8.1[b]	67.7
Pinampang	147.4	54.5	16.2	Lotong	264.6	29.7[b]	8.2
Lampaki	35.4	0.0	0.0	Pata	240.5	26.7	164.4

[a] No spraying
[b] One round in July-September 1991
[c] One round in March 1992

treated nets reported no such symptoms. No side effects were reported from villagers in the DDT area.

Giemsa-stained standardized thick blood films were examined at the VBDCP malaria reference laboratory in Kudat at the rate of 200 high-powered fields per slide before reporting a negative result. Parasitemic patients were given appropriate anti-malarial treatment by a VHV, whether symptomatic or not. Ethical considerations did not allow us to include an untreated control group of village. However, by chance a single village (Rondomon) remained unpsrayed due to DDT shortage and was monitored in the third year of the study.

The impact of insecticide intervention was determined separately for each village by combining all the parasite species. The incidence data had skewed distributions, so the non-parametric Wilcoxon and Mann-Whitney tests were used to compared the medians of unpaired samples. Two-sided p-values less than 5% were taken as statistically significant. In the baseline year, from November 1989 to October 1990, the median annual parasite incidence (API) rate was 271 per 1,000 population in the bednet villages (Table 1). In the DDT villages, the baseline incidence tended to be lower, the median being 199 per thousand, although this was not statistically significant ($p = 0.08$). All 22 villages showed a decrease in incidence over the first year of intervention, the median decrease being 211 in the bednet villages and 108 in the DDT ones ($p = 0.004$ in each case). Over the second year of intervention, eight of the eleven bednet villages showed a further decrease and another stayed constant at zero, with the overall median being a decrease of 15 ($p = 0.08$). Over the same period, the changes in DDT villages were more variable, six showing an increase and five a decrease (the median being an increase of 8, $p = 0.35$). Comparing the baseline to the final year of the study, the bednet villages showed a greater median decrease in incidence than the DDT ones (234 *vs* 88, $p = 0.02$).

It is possible that the PHC activities of village volunteers may have contributed to a downward trend in malaria since 1988 (6,041 and 5,683 presumptive malaria cases were treated in the DDT and netted groups respectively between November 1988 and October 1989), especially in combination with the introduction of vector control methods in both study groups (Fig 1). Significantly more presumptive cases were seen and treated in both groups (n = 9,142) one year (November 1989-October 1990) before intervention phase compared to the following year (n = 7143) ($x^2 = 8.24$, $p = 0.004$).

In the DDT villages the monthly malaria incidences showed a steady decrease in 1991 but increased progressively in 1992 compared with the corresponding months in 1990 (Fig 1). This increase

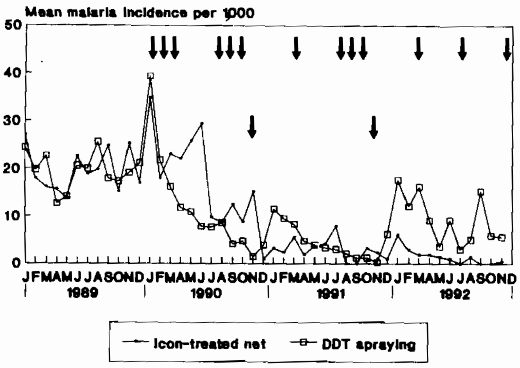

Fig 1–Mean malaria incidence in DDT and bednet groups before and after intervention. Upper and lower arrows indicate the months during which DDT spraying and bednet impregnation were carried out respectively.

was serious in Rondomon where DDT spraying was not carried out in 1992 (Table 1). However, there was no evidence of increased malaria resurgence in the bednet villages after the second retreatment of bednets (Fig 1). Quarterly cross-sectional blood surveys which were carried out only in the bednet villages revealed a progressive decline in slide positivity rates from 2.2% (n = 777, February 1991) to 0.74% (n = 1347, December 1991) and from 1.42% (n = 775, March 1992) to 0% (n = 1,235, November 1992). Unfortunately, no data were available from the DDT villages.

Although the trial was conducted in a more endemic area, the reduction in malaria incidence was comparable to that achieved by deltamethrin and permethrin in mainland China (Lu, 1992), but surpassed the results obtained in a previous trial in the Kinabatangan district, where subject compliance and lack of a primary health care program were major problems (Hii *et al*, 1987). A practical and easily executed bednet impregnation program, such as that reported here, is an additional tool for reduction of malarial transmission. It could assist or partially replace residual spraying and mass drug administration, especially in areas where these have proved less than totally successful or practical. It is hoped that following bednet retreatments intense health education and followup visits would reduce the infection rates to a low level.

The effects of lambdacyhalothrin impregnation on malaria incidence and slide positively rates observed in this study are encouraging, since children are at the greatest risk of developing severe complications of *P. falciparum* malaria. However, this powerful insecticide which did so well in bioassays (Njunwa *et al*, 1991) did not outperform permethrin in terms of reducing malaria fever rates among Tanzanian children (Lyimo *et al*, 1991). Rowland *et al* (1994) suggested that the longer residual life of lambdacyhalothrin which extended its effectiveness longer into the transmission season in Pakistan may explain the favorable impact on malaria prevalence in children. Alternatively, the fast acting, persistent, and excellent "kill rates against vector insects (Anon, 1993) suggest that lambdacyhalothrin is superior than the excito-repellency of DDT. There is no evidence that the purported primary vector of malaria, *Anopheles balabacensis*, have developed DDT resistance but populations of this mosquito have shown a reluctance to rest inside sprayed houses and pick up a lethal dose of the insecticide. The results justify a more detailed epidemiological evaluation of lambdacyhalothrin and extension of its use relative to DDT, especially in areas where the median API > 100 per thousand.

In Kudat district, where few people already possess mosquito nets, the method is not as cheap as in other areas where nets are already used widely. However, through an effective PHC system it was relatively easy to sell Government-subsidized mosquito nets (at US$3.15 and US$4.75 for a single and double net respectively) and net dipping as a community activity. We estimated the costs per person protected over the 3-year study were US$1.86 (M$4.10) for DDT spraying alone and US$0.72 (M$1.60) for bed net impregnation alone. These estimations allowed for field allowances for health supervisors and purchases of insecticides and nets, but excluded malaria control officer's transport, dipper's time, insecticide delivery, compression sprayers and government employee's salaries.

ACKNOWLEDGEMENTS

We are grateful to the ICI for supplying 'Icon' insecticide and Yayasan Sabah for funds to purchase polyethylene nets. We would like to thank the Director-General of Health Malaysia for permission to publish this article.

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