Acta Tropica, 49(1991)157–163
Elsevier

ACTROP 00138

Trial of pyrethroid impregnated bednets in an area of Tanzania holoendemic for malaria Part 3. Effects on the prevalence of malaria parasitaemia and fever

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(Received 26 July 1990, accepted 30 October 1990)

Children aged 1–10 in five villages were contacted fortnightly Their axillary temperatures, reports of fevers and blood slides were taken Following the introduction of permethrin impregnated nets into two estate villages the slide positivity for falciparum malaria declined markedly In traditional villages the introduction of impregnated nets had less convincing effects than in the estate villages and DDT spraying had no perceptible effect on malaria Over all villages there was a clear relationship between axillary temperature > 37 4°C, reports of fever and high parasitaemia We defined malaria fever in this way, and found in some cases significant reductions in occurrence of such fever following some time after introduction of permethrin impregnated nets No such effects were found with lambdacyhalothrin nets or with DDT spraying

Key words *Plasmodium falciparum*, Bednets, impregnated, Malaria morbidity, Slide positivity rate

Introduction

Encouraging results were obtained in reducing the number of infective mosquito bites by the introduction of impregnated bednets or by DDT spraying in five villages (Magesa et al , 1991) However, the test of whether this was of any human benefit is whether the prevalence of illness due to malaria was reduced

In holoendemic areas, adults build up a considerable degree of immunity to malaria, but children are more badly affected by the disease Even in children, there is not a simple relationship between *Plasmodium* infection and illness In the past there was a tendency in malaria eradication projects to consider only parasite infection However, recent trials in West Africa (Snow et al , 1988, Carnevale et al , 1988) have considered malaria attacks, and we have also made an attempt to assess illness due to malaria by taking children's axillary temperatures and enquiring about recent fevers, before taking blood slides

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0001-706X/91/$03 50

Methods

The work was carried out in two estate villages, Mlingano and Umba, with brick houses and tiled roofs, and three traditional villages, Kumbamtoni, Mindu and Mng'aza, with mud houses and thatch roofs (Njunwa et al , 1991)

Children aged 1–10 presenting voluntarily, with or without their parent or guardian, were met by arrangement in each of the five villages every two weeks A questionnaire was completed, including questions about name, age, use of a bednet, indications of fever during the previous two days, etc The axillary temperature was taken with an electronic thermometer and a thick blood film was taken if the temperature was > 36 9°C, or if there had been a report of fever In a sample of cases, slides were taken even without these indications

The slides were returned to the Ubwari Field Station, Muheza, stained with Giemsa and examined for malaria parasites The number of parasites per 200 white blood corpuscles was counted The day after taking the slides, the team returned to the village concerned to report the results and to arrange that the children diagnosed as malaria positive received chloroquine treatment at the nearest Health Centre Seriously ill patients were transported to the Teule Hospital at Muheza

The data from the questionnaires, thermometer readings and blood slides were stored on a computer using a double entry system with cross-checking for data entry errors devised by Miss K Rowan and based on the system which she developed for malaria control trials in The Gambia

At approximately six-month intervals, mass blood surveys were carried out on as many as possible of the children in each village who were searched for in their homes A slide was taken from each, regardless of whether there were indications of fever

Results and Discussion

Slide positivity

The upper 2 or 3 lines in Figs 1 and 2 show the quarterly averages of the percentages of slides from the fortnightly routine surveys which were positive for malaria parasites, almost all of which were *P falciparum* The lower 2 or 3 lines show the percentages with high parasitaemia (> 100 parasites/200 w.b c) The results from the mass surveys ('double' symbols in Fig 1) were generally similar to those shown in the figures for the fortnightly routine surveys Fig 1 indicates that the initial SPR (slide positivity rate) was somewhat lower in Mlingano (40–65%) than in Umba (60–80%) This is probably connected with the better state of the houses at Mlingano making them less favourable for mosquito entry, the lower sporozoite inoculation rate from the mosquito population (Magesa et al , 1991) and the fact that parents at Mlingano are generally better educated and more likely to treat their children with chloroquine at the first signs of fever After the introduction of permethrin impregnated nets into Mlingano in September 1987, there was a prolonged downward trend in SPR to a final value of about 20% When permethrin impregnated nets were introduced into Umba there was a decline in the percentage of children with high parasitaemia (20% to less than 10%) and a slight decline in SPR to 50%

Fig 2 shows that the traditional villages of Kumbamtoni, Mng'aza and Mindu

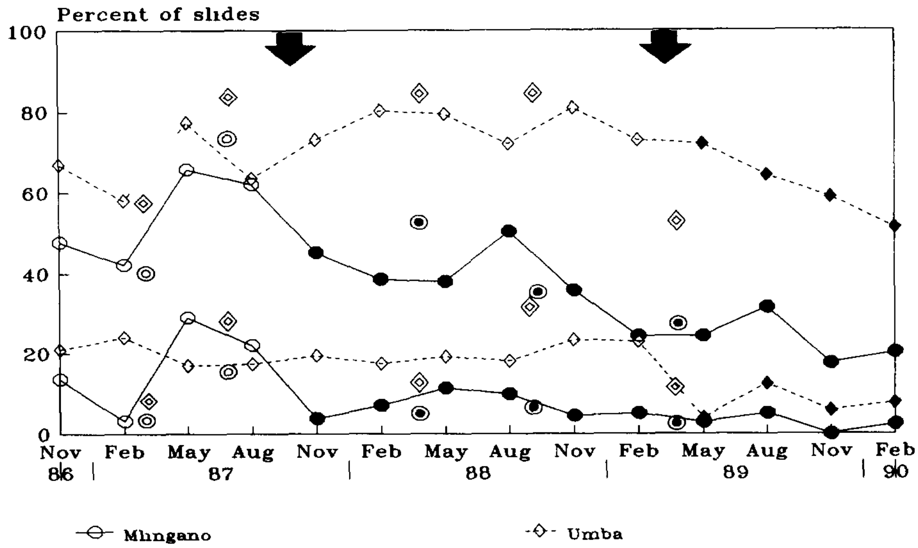

Fig 1 Slide positivity (upper pair of lines) and percentage of slides showing high parasitaemia (> 100/200 w b c , lower pair of lines) in Mlingano and Umba Blackened symbols indicate when impregnated nets were in place The left arrow indicates the time of introduction of permethrin impregnated nets into Mlingano and the right arrow indicates the introduction of similar nets into Umba

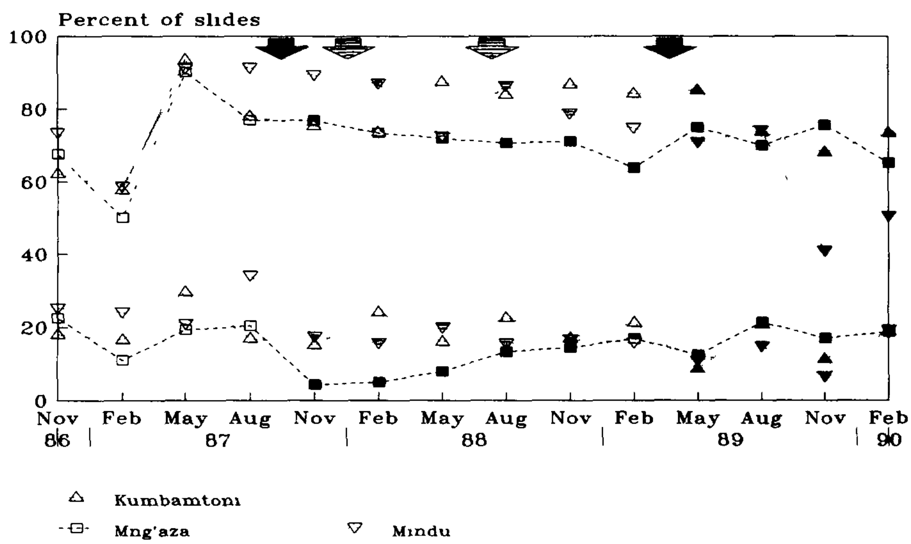

Fig 2 Slide positivity (upper lines) and high parasitaemia (lower lines) in Mng'aza, Kumbamtoni and Mindu The left arrow indicates introduction of permethrin impregnated nets into Mng'aza the hached arrows indicate DDT spraying in Mindu and the right arrow indicates introduction of lambdacyhalothrin impregnated nets into Kumbamtoni and Mindu

started with very high SPR levels (60–90%) Soon after introduction of permethrin nets into Mng'aza there were indications of a decline in the rate of high parasitaemia (from 20% to 5%) and, during 1988, the SPR seemed to be depressed compared with Kumbamtoni The reduction in SPR was never as convincing as in Mlingano, presumably because the mosquito population and sporozoite inoculation rate remained much higher in Mng'aza than in Mlingano (Magesa et al, 1991) Differences between Mng'aza and Kumbamtoni disappeared when Kumbamtoni also received impregnated nets in April 1989

Fig 2 also shows that DDT spraying in Mindu had no apparent impact on SPR or rate of high parasitaemia After introduction of lamdacyhalothrin impregnated nets in April 1989, the SPR in Mindu declined, and reached the lowest levels recorded in that village (40–50%) in the last two three-month periods of the trial The mosquito population and sporozoite rate was no more strongly reduced by the insecticidal nets than by the DDT spraying (Magesa et al, 1991) but these parameters do not take into account the personal protection conferred on net users which is not provided by house spraying

Fig 3 shows the geometric mean parasite densities in positive slides, in all five villages These show that in Mlingano the nets had a definite impact on the level of parasitaemia (values in the last year of the trial less than 20/200 w b c) There are indications of similar effects in the first year after net introduction at Mng'aza and Umba but at other times and villages, no such effects occurred

Malaria fever

Table 1 analyses the computer-stored data from all the villages and 3 age groups on the relationship of reports or measurements of fever to malaria parasitaemia As is well known, temperature fluctuates in malaria patients and our reports of fever were from sources who may have varied in reliability Nevertheless there was a correlation of measured temperature with reported fever — among the youngest children with a temperature measured as > 37 4°C there were reports of fever for 64%, but in the same age group with measured axillary temperature < 37°C reports of fever were made for only 16%

The SPR was over 55% in the older children and over 70% in the younger ones

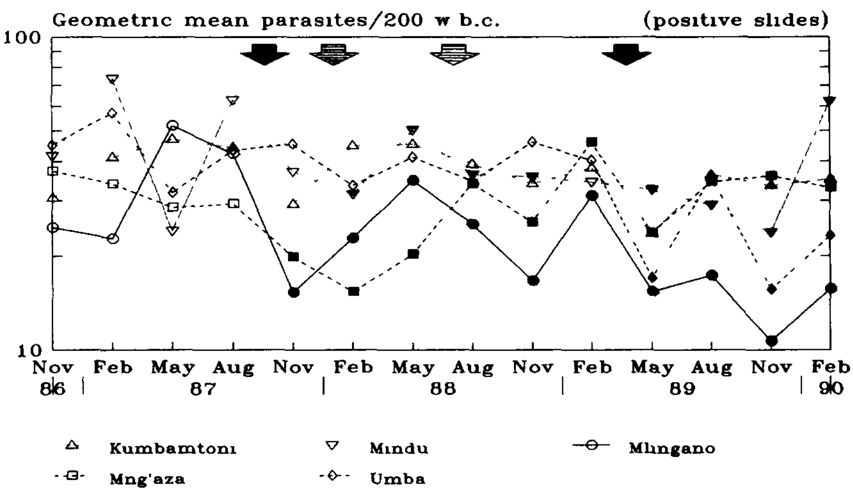

Fig 3 Geometric mean parasitaemias in positive slides from the fortnightly surveys in all five villages Symbolism as in Figs 1 and 2

TABLE 1

Relationship, for all villages combined, of parasitaemia and high parasitaemia (> 100 parasites/200 w b c) to axillary temperature and to reports by the child or guardian that the child had fever during the preceding two days Slides were taken from almost all the children with temperatures >36 9°C and/or where fever was reported, but only from a sample of the other children Data are presented for three age groups of children

Fever reported	No			Yes		
Temperature	<37 0	37 0–37 4	>37 4	<37 0	37 0–37 4	>37 4
Age 1–2						
No seen	1862	523	61	354	144	110
% parasitaemia	71 74	70 08	76 67	79 30	79 58	90 91
% high parasit	24 64	18 73	33 33	31 85	30 38	59 09
Age 3–4						
No seen	2287	804	85	160	110	60
% parasitaemia	66 67	62 64	63 86	66 67	70 00	83 33
% high parasit	13 33	9 66	20 48	15 56	12 73	45 00
Age 5–10						
No seen	5593	1611	122	263	147	60
% parasitaemia	56 21	59 06	59 02	58 60	58 33	58 33
% high parasit	5 59	6 53	16 39	13 95	13 89	18 33

even with no sign of fever and this rate was only moderately increased in those with fever However, there was clearer evidence that high parasitaemia caused many of the fevers from which children suffer in these villages — both reported and measured fever correlated with high parasitaemia and in those with reported fever and temperature >37 4°C the rate of high parasitaemia was several times higher than in those without fever symptoms Thus it was decided to adopt the following criteria for defining a case of malaria fever — temperature >37 4°C, and/or reported fever, and parasitaemia >100/200 w b c

Table 2 shows the percentage of children contacted in each village who were diagnosed as having malaria fever in the different phases of the project It is clear that it would have been better if resources had permitted us to have worked in a much larger sample of villages and to use villages, rather than individual children, as the unit of sampling (Snow et al., 1988, W H O , 1989). Furthermore, between phases 1 and 2, there was a marked increase in the malaria fever rates in the villages of Umba and Kumbamtoni which did not then have nets. This was unfortunately due to the fact that the taking of temperatures had been poorly supervised before this time and often skin contact with the thermometer had not been ensured – inspection of the records revealed a number of instances of implausibly low temperatures recorded To train the team in the correct technique, over a period of several months, a thermometer was used under each armpit and close agreement of the two was required before a record was accepted

This poor temperature measurement must also have affected the villages which received nets Table 2 shows that in phase 2 of the trial, whereas the numbers of recorded malaria fever cases increased in the control villages of Umba and Kumbamtoni, they stayed approximately constant in Mlingano and Mng'aza where nets were introduced To test this apparent difference in trend, Bartlett's test was used (Armi-

TABLE 2

Percentage of contacts where the child was diagnosed as having malaria fever, defined as an axillary temperature > 37 4°C, and/or a report of fever, and with a parasitaemia > 100/200 w b c The number of contacts (N) on which the percentages are based are indicated The table is divided into the phases of the trial in which different vector control measures were introduced Presence of permethrin impregnated nets is indicated by solid boxes, lambdacyhalothrin nets by boxes with broken lines and DDT spraying by a double box

		Phase 1 (Oct'86–Sept'87)	Phase 2 (Oct'87–Mar'89)	Phase 3 (Apr'89–Mar'90)
Mlingano	%	1 94	1 82	0 61
	N	1444	2253	819
Umba	%	2 80	4 18	0 47
	N	1206	1149	425
Mng'aza	%	2 19	2 68	2 38
	N	774	1118	359
Kumbamtoni	%	2 83	4 40	4 42
	N	988	1204	587
Mindu	%	2 91	2 72[a]	3 95
	N	996	772[a]	481

Significance tests Factor	Village(s)	Phases	χ^2
Permethrin	Mling & Mng vs Umba & Kumb	1 vs 2	2 05 n s
Permethrin	Umba	1 + 2 vs 3	10 14 (P<0 01)
Continued progress with permethrin	Mling	2 vs 3	5 16 (P<0 05)
	Mng	2 vs 3	0 04 n s
DDT	Mindu vs Kumbamtoni	1 vs 2	1 50 n s
Lambdacyhalothrin vs permethrin	Umba vs Kumb	3 vs 1 + 2	10 70 (P<0 01)
	Umba vs Mindu	3 vs 1	7 86 (P<0 01)

[a]Data from Jan -Dec 1988 when DDT was sprayed

tage and Berry, 1987) It yielded a χ^2 value which did not reach the level of statistical significance (Table 2) However, when Umba received impregnated nets in phase 3, the malaria fever rate there declined significantly

There was a significant decline between phase 2 and 3 in the malaria fever rate in Mlingano but not in Mng'aza It may be recalled from Fig 1 that the introduction of nets into Mlingano seemed to trigger a prolonged decline in SPR, suggesting that the initial benefit of the nets may have been compounded by the decline which this produced in the reservoir of infection This underlines the desirability of continuing trials of this kind for more than a few months so that the full consequences of interventions can be seen

Comparison of the malaria fever rates in Mindu and Kumbamtoni in phases 1 and 2 showed no significant effect (Bartlett's test) of the DDT spraying

It had been hoped that the powerful insecticide lambdacyhalothrin, which performed so well in bioassays (Njunwa et al , 1991), would perform better than permethrin in controlling malaria However, comparison of the malaria fever rates after permethrin nets were introduced in phase 3 into Umba, and lambdacyhalothrin nets were introduced into Kumbamtoni and Mindu, suggest that the impact of the more powerful insecticide was no better, and actually seemed to be significantly worse, than permethrin (Table 2) It must be recalled that there are social and entomological differences between these villages, so the significant difference shown at the bottom of Table 2 may be misleading Nevertheless, we conclude that the more powerful insecticide did not prove strikingly more effective in disease control, and this agrees with the results from incidence rates after clearance of parasitaemias by chemotherapy (Msuya and Curtis, 1991) The minor, but unpleasant, side-effects of lambdacyhalothrin E C on nets (Njunwa et al , 1991) would seem to make it less acceptable for net dipping by the community, and in the absence of evidence that it controls malaria better, it seems advisable to use a more benign compound or formulation

The villages were small and close enough to other untreated villages for movements of mosquitoes and people to affect the results Better malaria control may well be achievable if groups of villages are provided with nets

Acknowledgements

We thank the team from the Ubwari Field Station who collected and read the blood slides, and the children of the experimental villages who tolerated having their fingers pricked with fortitude The project received financial support from the UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases, the Tanzanian Ministry of Health and the British Medical Research Council This paper is published by permission of the Director of the Amani Centre and the Director General of the Tanzanian National Institute for Medical Research

References

Armitage, P and Berry, G (1987) Statistical Methods in Medical Research, 2nd edn , Blackwell, Oxford, p 459

Carnevale, P , Robert, V , Boudin, C , Halna, J -M , Pazart, L , Gazin, P , Richard, A and Mouchet, J (1988) La lutte contre le paludisme par des moustiquaires impregnees de pyrethrinoides au Burkina Faso Bull Soc Pathol Exot 81, 832–846

Magesa, S M , Wilkes, T J , Njunwa, K J , Mnzava, A E P , Myamba, J , Kivuyo, M D P , Hill, N , Lines, J D and Curtis, C F (1991) Trial of pyrethroid impregnated bednets in an area of Tanzania holoendemic for malaria Part 2 Impact on the mosquito populations Acta Trop 49, 97–108

Msuya, F H M and Curtis, C F (1991) Trial of pyrethroid impregnated bednets in an area of Tanzania holoendemic for malaria Part 4 Effects on incidence of malaria infection Acta Trop 49, 165–171

Njunwa, K J , Lines, J D , Magesa, S M , Mnzava, A E P , Wilkes, T J , Alilio, M , Kivumbi, K and Curtis, C F (1991) Trial of pyrethroid impregnated bednets in an area of Tanzania holoendemic for malaria Part 1 Operational methods and acceptability Acta Trop 49, 87–96

Snow, R W , Lindsay, S W , Hayes, R J and Greenwood, B M (1988) Permethrin impregnated bednets prevent malaria in Gambian children Trans R Soc Trop Med Hyg 82, 838–842

World Health Organization (1989) The use of impregnated bednets and other materials for vector borne disease control Report of an informal WHO/VBC consultation WHO/VBC/89 981