

# EPIDEMIC MALARIA AMONG TRANSMIGRANTS IN IRIAN JAYA

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## ABSTRAK

### EPIDEMI MALARIA PADA TRANSMIGRAN DI IRIAN JAYA

*Malaria merupakan masalah kesehatan yang penting untuk masyarakat transmigrasi di daerah endemisitas malaria tinggi seperti Irian Jaya. Di Arso, epidemi malaria timbul setelah dua sampai enam bulan sesudah tibanya transmigran baru. Dalam tiga bulan angka parasitemia bisa mencapai 70% dan hampir 10% dari transmigran mendapat malaria berat yang membutuhkan rujukan ke rumah sakit dalam enam bulan pertama.*

*Usaha penanggulangan malaria di daerah seperti Arso menghadapi berbagai tantangan dan hambatan karena tingginya derajat resistensi parasit terhadap klorokuin, fasilitas dan kemampuan untuk diagnostik yang terbatas, sulitnya pengendalian vektor (*An. punctulatus* group) dan tidak adanya strategi untuk menghilangkan sumber infeksi yang asimtomatik.*

*Berbagai usaha yang dapat mengurangi risiko epidemi malaria di daerah transmigrasi Irian Jaya ialah antara lain pemberian profilaksis selama tiga bulan (selain klorokuin perlu dipertimbangkan pemberian primaquin bagi transmigran yang tidak hamil dan tidak menderita defisiensi G-6-PD), peningkatan fasilitas diagnostik dan pengobatan/termasuk rujukan untuk kasus malaria berat), pemakaian kelambu, penemuan kasus aktif untuk menghilangkan gametocytemia yang asimtomatik (selama enam bulan) serta penyuluhan dan partisipasi masyarakat dalam pemberantasan malaria (termasuk pembinaan kader kesehatan).*

*Untuk melaksanakan kegiatan tersebut di atas perlu disediakan tenaga dan sumber dana yang khusus.*

## INTRODUCTION

Endemic malaria impedes socioeconomic development wherever it occurs. Malaria contributes to a cycle of infection, disease and poverty. Communities affected by malaria often

lack the infrastructure and economic resources to defend themselves against malaria, and the disease restricts the development of those resources. Perhaps the most effective approach to breaking this cycle is economic intervention, i.e., development of a social and economic base

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to support a broad spectrum of malaria control activities. Such measures would include not only strategies that directly attack the parasite and vector, but also those which empower citizens to fight against the disease and increase motivation, education and organizational skills.

Broad institution of these elements may be impractical because reaching and maintaining a presence in remote malarious areas is often difficult. On the other hand, linking community-based control strategies to targeted economic development programs offers an opportunity to overcome that difficulty. When planners of such activities include the development of rational malaria control activities, and set aside the resources to achieve specific goals, then abatement of endemic malaria may ensue. This may be especially important since abrupt economic development activities often begin with social and environmental changes that may destabilize and exacerbate malaria.

Transmigration in Indonesia represents a positive economic intervention which may serve as a platform for a broad spectrum of malaria control activities. This programmatic spurring of social and economic development creates ideal circumstances for instituting rational plans for the control of endemic malaria. The huge investment of financial and manpower resources for transmigration dwarfs the resources and effort required to simultaneously install measures to minimize morbidity and mortality due to malaria. Moreover, the motivation to do so should be compelling from the practical prospective of protecting the large investment of people and resources that any transmigration project represents.

An important difficulty with committing to malaria control at the outset of a transmigration project is confidence in the plan. Indonesia

presents a wide array of malarious environments; no single plan could be universally effective. Control measures are best tailored to the local habitat, both in a biological and socioeconomic sense. Nonetheless, the technical detail required for development of site- or region-specific malaria control is within our reach. In many instances, an awareness of the published scientific literature may be sufficient to develop a rational plan. Reliable information about malaria provides confidence in the plans to control it.

The term 'reliable' should not be confused with 'sophisticated'. High biotechnology and the thrilling advancements at its cutting edge are not essential for protecting transmigrants and indigenous people from malaria. A disciplined application of 'low-tech' research alone may provide enormous dividends in public health. Limited ability to participate in high biotechnology work should not compromise confidence in ability to develop effective and practical measures of malaria control.

In this article we shall examine the problem of epidemic malaria among new transmigrants in the Arso region of Irian Jaya, and then consider the results of collaborative studies between the Communicable Diseases Research Centre of the National Institute of Health Research and Development (LITBANGKES), the Irian Jaya Provincial Health Service, and the U.S. Naval Medical Research Unit No. 2 (NAMRU-2). These shall be analyzed as though developing a rational approach to avoiding the problems of epidemic malaria in new transmigrant communities in northeastern Irian Jaya. The reader may benefit by recognizing the 'low-tech' nature of the observations gathered in Irian Jaya. No deficiency in technical capability should prohibit similar studies in other areas of Indonesia by other investigators.

## EPIDEMICS

An outbreak of malaria justifiably creates alarm and an atmosphere of crisis. Outbreaks occur typically in conjunction with the movement of nonimmune people into hyper- to holoendemic malarious areas, such as transmigration to the Arso region of northeastern Irian Jaya. In Arso, epidemics usually occur within two to five months of arrival. This incubation period represents the consolidation of forces which create the epidemic; infection, transmission and reinfection. A cascade of disease occurs as more and more individuals contribute to the pool of infectious gametocytes. In transmigration villages where epidemics occur, one must examine the measures taken to prevent disease and rationally consider the reasons for inadequate malaria control.

First, we shall examine data that illustrate the onset of epidemic malaria. In Arso PIR II in 1988 surveys of blood films were conducted during the first months of residence. Figure 1 illustrates those results. Infection pressure was apparently intense upon arrival; 14% were infected after just 10 days (the biological incubation period is 8 to 14 days). Within just three months over 70% were parasitemic. Another study of epidemic malaria among new transmigrants focused on Arso PIR IV in 1992 (Figure 2). Here the onset of the epidemic was slower. The difference between these two villages may be related to the populations of infected local Irianese people: large numbers in Arso PIR II and relatively few in Arso PIR IV. The extant pool of infectious gametocyte carriers in PIR II caused an immediate epidemic, whereas several months were required before the new arrivals themselves established their own pool of infectivity in PIR

IV. Figure 3 shows the prevalence of symptoms of malaria consistent with uncomplicated malaria (without slide confirmation) in Arso PIR IV, and Figure 4 shows the incidence density of severe malaria. These observations demonstrate the devastating impact of endemic malaria on a community of newly exposed people. For example, 91 cases of severe malaria occurred among the one thousand residents of Arso PIR IV during their first 6 months, i.e., roughly 10% of the population; among these, several deaths were reported.

The data of Figures 1 to 4 raise two important questions: 1) How could such spiking of infection and disease occur in the face of chemoprophylaxis, chemotherapy, and vector control activities? and 2) What could prevent such an epidemic? Addressing these questions largely accounts for the remainder of this text. The discussion also illustrates the utility of basic information gathered from field-based studies in grasping the force of key determinants of malaria in isolated areas. Understanding these features assists the formulation of control strategies.

## DETERMINANTS OF EPIDEMIC MALARIA IN A NEW COMMUNITY

### Force of infection.

In the Arso region of Irian Jaya, the incidence of malaria has been measured to be between 2 and 5 infections per person year.<sup>1,2</sup> In other words, the average man, woman and child may be expected to experience 2 to 5 infections by malaria parasites during the course of a single year. Most residents of new transmigration villages in Arso will develop malaria within just a few weeks or months, as seen in Figures 1 and 2.

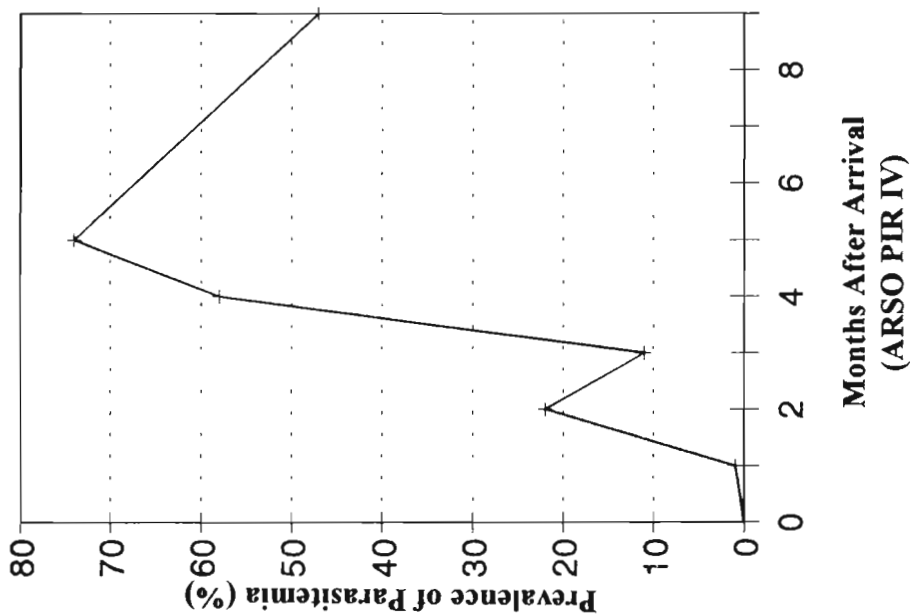


Fig. 2

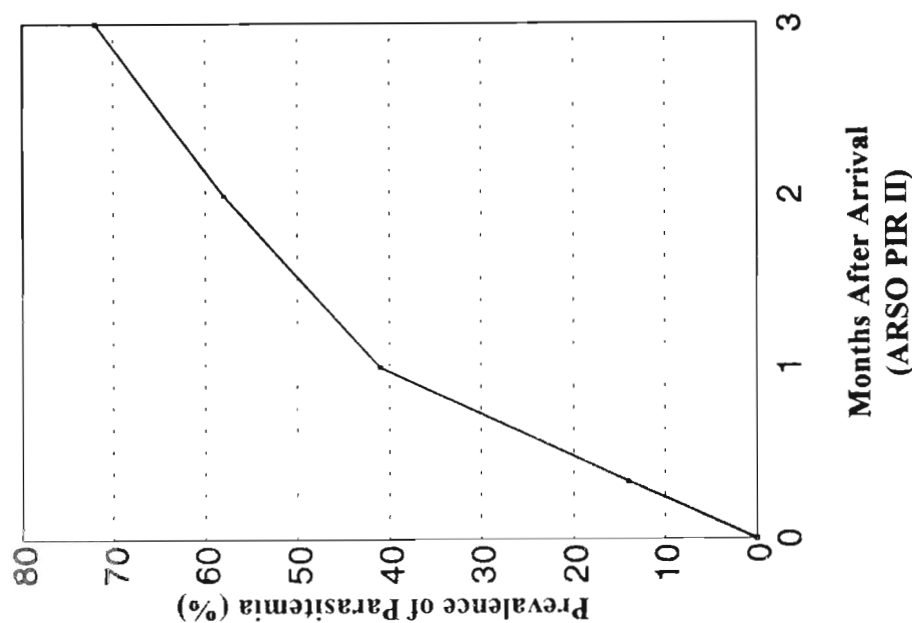
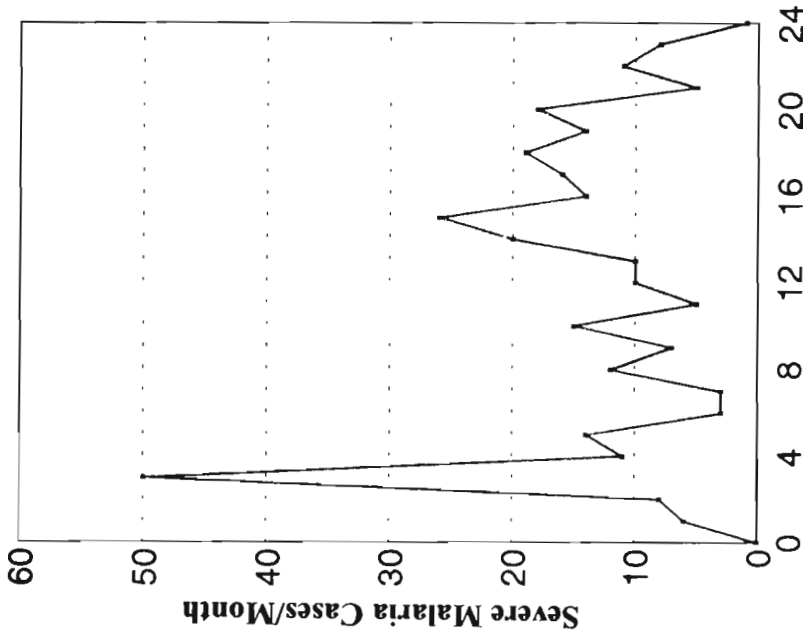


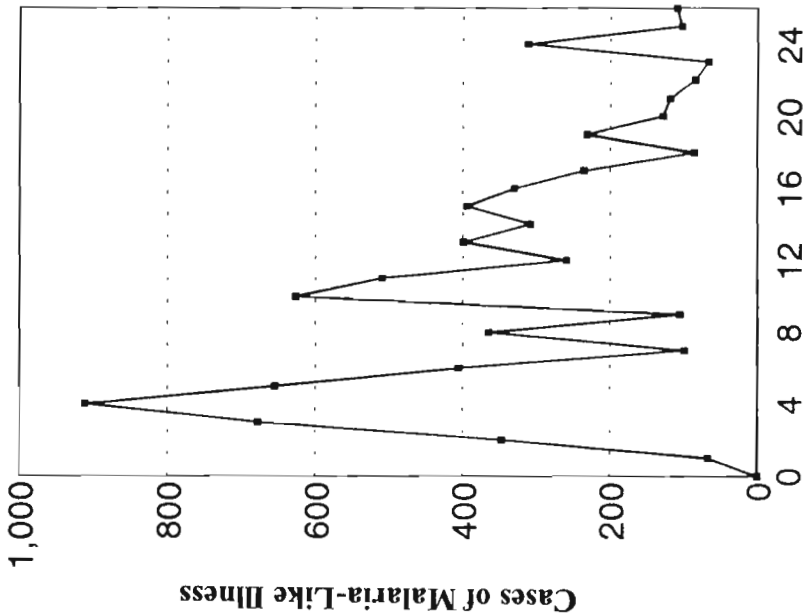
Fig. 1

### Prevalence of Malaria in New Communities in Arso, Irian Jaya



Months After Arrival (ARSO PIR IV)

Fig. 4



Months After Arrival (ARSO PIR IV)

Fig. 3

### Morbidity Due to Malaria in a New Community in Arso, Irian Jaya

Other villages in the Arso region have had lower attack rates of malaria. For example, in Arso X and Arso XI during 1992 and 1993, these new villages had <1 infection per person year (C. Ohrt and D. Fryauff, unpublished). This may be the result of the research-related clinics which operated continuously in those villages for over two years. Those clinics offered routine microscopic diagnosis and prompt therapy of malaria 24 hours a day, seven days a week in support of the routine services offered by the resident nurse. Prompt, accurate diagnosis followed by proper therapy and compliance -- these measures alone appear to greatly curtail infection pressure in transmigration villages, and appear to be key components of malaria control.

Malaria transmission requires mosquitoes. The force of infection created by mosquitoes in Arso has been measured (M.J. Bangs and B.A. Annis, unpublished, as described by J.K. Baird in reference 2). Each night, approximately 15 potential vectors feed upon an unprotected person. With an average sporozoite rate (the percent of anophelines carrying sporozoites) of about 1%, this means that the average exposure of a person in Arso will be one infective bite about once each week. Fortunately, the natural efficiency of inoculation, i.e., the percent of these potentially infectious bites that result in patent malaria, may be just 10%.<sup>3</sup>

#### **Naturally acquired immunity and inborn resistance.**

Debilitating episodes of spiking fevers, chills and malaise typically occur in people without prior exposure to malaria infection, with a significant risk of death in naive persons infected with *Plasmodium falciparum*. Figures

1 to 4 demonstrate the susceptibility of nonimmune people to endemic malaria. In contrast, adults with lifelong exposure to heavy infection pressure only occasionally show symptoms of malaria, even when parasitemic. Naturally acquired immunity to malaria is the basis of this difference and has been the subject of many research studies in Irian Jaya.<sup>4-8</sup> Natural immunity fails to develop where malaria is epidemic, hypoendemic or mesoendemic. For example, there is insufficient transmission of malaria on Java or Bali for residents to develop naturally acquired protection. The risk of acquiring malaria on Java is diminishingly small outside of the few foci of chronic endemicity; as low as 2 cases per 100,000 person years.<sup>9</sup> Inborn abnormalities such as G-6-PD deficiency or sickle cell anemia may protect against malaria but these occur only rarely among Javanese.<sup>10</sup> Javanese or Balinese transmigrants may be considered nonimmune to malaria when they first arrive at their new village. They are as susceptible to fulminant and life-threatening episodes of malaria as visitors from Jakarta or other non-malarious areas of the world such as Europe or North America.

#### **COUNTERMEASURES AGAINST EPIDEMIC MALARIA**

##### **Prophylaxis.**

Transmigrants coming to Irian Jaya receive weekly prophylaxis with chloroquine. As a general rule, most comply. Chloroquine prophylaxis was administered in Arso PIR IV in 1992,<sup>11</sup> yet an epidemic of malaria occurred in this community. Does chloroquine offer protection?

Our data suggest that in the Arso region, chloroquine offers only limited protection against malaria infection. Figures 5 and 6 support this finding. On the other hand, chloroquine may offer some protection against clinical illness. Health care practitioners report reasonable success in resolving malaria symptoms when treating patients with chloroquine in the Arso region, even if the infection itself is not cured. However, clinical protection may not occur in new transmigrants on chloroquine prophylaxis, as the doses used for prophylaxis are less than those used for treatment. In a year long study of malaria prophylaxis in Arso XI, there were no significant differences in either the incidence of malaria parasitemia (Figure 6) or in the frequency of symptoms associated with parasitemia when study participants on chloroquine prophylaxis were compared to study participants on placebo (D. Fryauff, unpublished).

Practical options to chloroquine for prophylaxis of transmigrants are few. A prophylactic agent for use in this environment should be safe and well tolerated, effective, affordable, and readily available. There are no known agents that satisfy all these criteria. For example, chloroquine satisfies all of these criteria except one; it is not very effective. Conversely, a highly effective agent of prophylaxis that is prohibitively expensive or too toxic for general use is also not helpful. Compromise is necessary and should be carefully weighed in light of sound evaluations of new agents

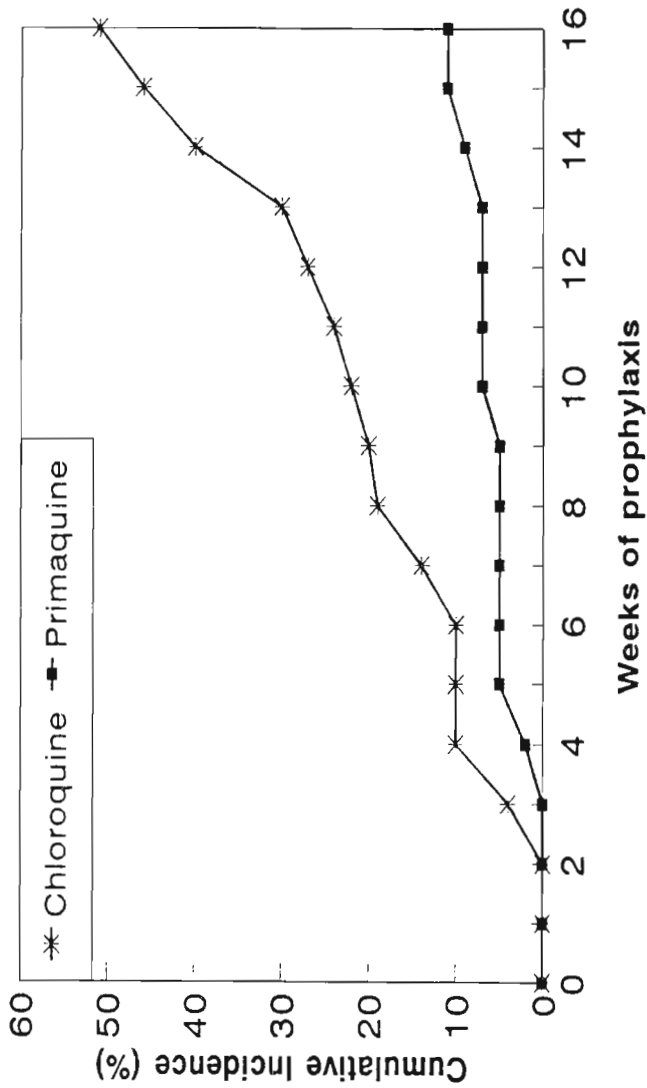
An additional consideration is that it is to the benefit of new transmigrants, who will be residing long term in a malarious area, to

develop naturally acquired immunity (NAI) to malaria. Less effective antimalarials may assist the development of NAI. For example, when used as treatment, chloroquine provides relief to most patients by limiting clinical illness; however, it also results in persistent or recrudescing parasitemia in 70 to 90% of cases. This strong stimulus to the immune system may accelerate the development of NAI. In contrast, highly effective antimalarial drugs restrict or prevent exposure to blood stage parasites, and may just postpone, rather than prevent, epidemics of malaria in new transmigrants. Data are needed to address this issue.

One possible alternative to chloroquine is primaquine. During 1992 to 1994 two research trials evaluated primaquine for chemoprophylaxis against malaria in nonimmune Arso transmigrants. Both trials included a group receiving chloroquine. Figures 5 and 6 show that primaquine was effective prophylaxis against falciparum and vivax malarias among transmigrants in Arso. These two studies suggested that daily primaquine doses were well tolerated and did not cause significant toxicity<sup>12,13</sup>.

Primaquine has not been safety tested for use during pregnancy and can cause hemolysis in some people with genetic deficiency in erythrocytic glucose-6-phosphate dehydrogenase (G6PD) activity. Thus primaquine is safest when pregnancy and G6PD testing are carried out before administration. A commercial kit for G6PD testing costs roughly US\$0.65 per test at retail (NADPH "Spot Test" for G6PD deficiency, Sigma Chemical Co., St. Louis, Missouri, USA). For these reasons, pregnant women and any individuals with G6PD deficiency were excluded from the two trials described above.

### Cumulative Incidence of Malaria Alternate Day Primaquine Trial. Arso X, Irian Jaya

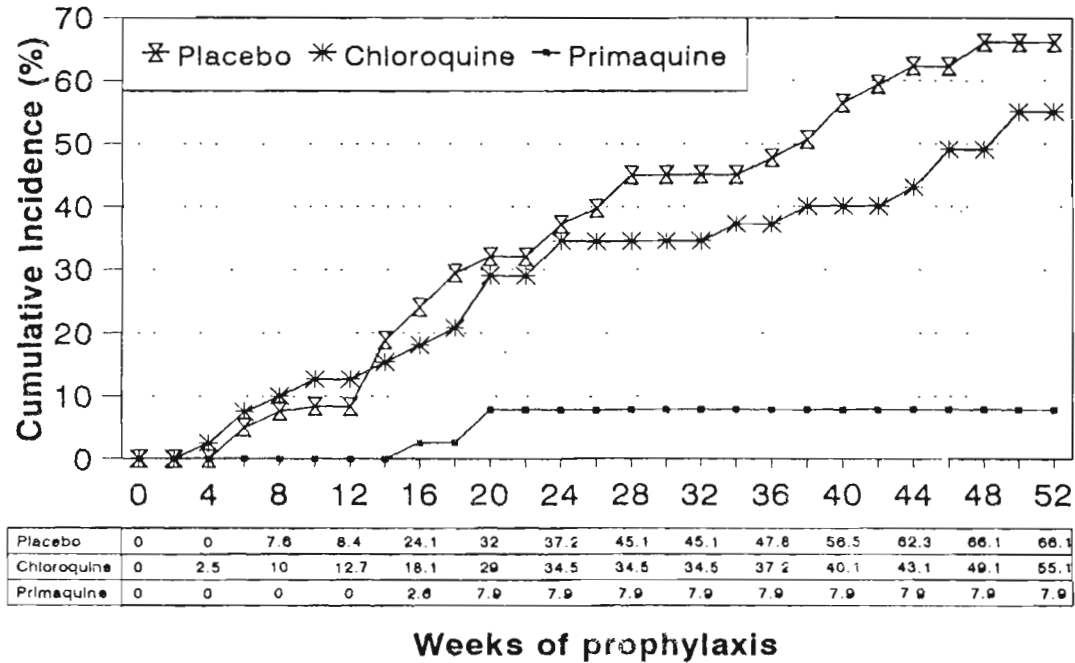


December 1992- April 1993

Fig. 5



## Cumulative Incidence of Malaria Daily Primaquine Trial. Arso XI, Irian Jaya



July 1993 - August 1994

Fig. 6

Taking these considerations into account, primaquine prophylaxis may be a suitable alternative to chloroquine for protecting non-pregnant, G6PD-normal transmigrants from the onslaught of epidemic malaria. It carries the theoretical problem of preventing any exposure to blood stage parasites as it acts to kill liver stages before their release into the blood stream; thus persons on primaquine would have reduced opportunity to develop NAI to the blood stage parasites that cause clinical disease.

Two additional drugs have been shown to be highly effective prophylactic agents in the Arso region. In a recent trial, both weekly mefloquine and daily doxycycline provided nearly 100% protection against malaria parasitemia (C. Ohrt, unpublished). Doxycycline is available in Indonesia, although it is more expensive than chloroquine, particularly as it must be taken on a daily basis. Mefloquine is expensive and not available in Indonesia, but is easy to take and reasonably safe and well tolerated. Neither of these agents can be given to pregnant women (although there is now some experience with using mefloquine in pregnancy). Mefloquine is not recommended for infants, and doxycycline is not recommended for children less than eight years of age because it may cause abnormalities of bone and tooth development in younger children.

### Case Detection.

Nurses residing in transmigration villages shoulder the responsibility for primary diagnosis and treatment of malaria. They generally have no on-site capability for microscopic diagnosis of malaria. Instead, they rely upon clinical presentation of patients with symptoms of malaria. This may largely explain

the runaway course of malaria epidemics in new transmigration villages. Reliance upon clinical presentation for diagnosis of malaria, especially in villages under mass chloroquine prophylaxis, may accurately diagnose many of the symptomatic malaria infections. However, reliance on clinical criteria leaves undetected a pool of asymptomatic carriers, who contribute significantly in creating a rapidly burgeoning cycle of infection and reinfection, i.e., an epidemic. Actively seeking asymptomatic infections and instituting effective therapy breaks this cycle. Of course, this requires a practical means of diagnosis.

Several methods for diagnosis of malaria are now available. The Becton-Dickinson Company sells two kits; the QBC<sup>®</sup> fluorescent capillary tube system and ParaSight<sup>®</sup> Test dipstick system. These systems, in particular the dipstick test, offer the advantage of requiring relatively little expertise. It is not difficult to imagine the dividends in public health by having resident nurses routinely making reliable diagnoses of malaria with ease. However, this is not now economically practical. Each of these new tests costs about US\$1. A kabupaten making 100,000 diagnoses of malaria each year must allocate US\$100,000. Bearing this cost must be weighed against that of training and equipping nurses to make a conventional diagnosis of malaria using Giemsa staining and microscopic examination. In our view, the conventional diagnosis may be a superior alternative in an endemic setting because the expenditure creates a pool of diagnostic expertise whereas the two new systems do not establish such residual benefits.

Researchers have evaluated the QBC<sup>®</sup> and ParaSight<sup>®</sup> systems in Irian Jaya.<sup>14-16</sup> In general, these systems are not sensitive below about 100 parasites per microliter of blood. Low parasitemias are often characteristic of both

highly sensitive non-immune Javanese and Balinese transmigrants experiencing the first symptoms of malaria illness and the relatively immune Irianese residents of Arso communities. In addition, the ParaSight® test only detects *P. falciparum*, and thus provides falsely negative results in all patients with *P. vivax* infection. Development of a similar dipstick test for *P. vivax* is underway.

### Therapy.

Resistance to chloroquine raises many difficult issues. Patients often remain parasitemic following treatment and, because gametocytes are either generated by surviving asexual blood forms or persist after therapy, they ultimately infect others. The poor efficacy of chloroquine in curing bloodstage infections in Arso is illustrated in Table 1. One may argue that chloroquine serves to protect people against severe malaria. However, chloroquine thus applied creates a pool of asymptomatic carriers of viable gametocytes, as chloroquine has no effect upon gametocytes. This places the

community at risk of infection and invites a worsening resistance situation. Alternative or supplemental therapies may better manage the epidemic phase of malaria in new communities.

Collaborative Litbangkes-NAMRU-2 research activities in Irian Jaya have been designed to address this problem. A strategy for therapy of malaria in Irian Jaya should include measures to kill incubating or dormant liver stage parasites and for neutralizing gametocytes in addition to the asexual blood stages usually targeted by treatment. Primaquine is the only currently available antimalarial that achieves both effective cure of liver stages and sterilization of circulating gametocytes. Thus, adjunctive primaquine therapy should be considered for non-pregnant G6PD-normal patients with malaria. Another benefit of primaquine, against *P. vivax* only, would be more effective chloroquine therapy. Studies in Arso revealed that adjunctive primaquine therapy rendered chloroquine-resistant vivax malaria<sup>17</sup> blood stage infection susceptible to standard chloroquine therapy (Table 2).<sup>18</sup>

**Table 1. Seven day in vivo tests of resistance to chloroquine by *Plasmodium falciparum* in the Arso region of Irian Jaya, 1987-1994.**

Classification*	Number of Patients	Proportion
S/RI	66	50%
RII	42	32%
RIII	24	18%

\* Standard WHO case definitions applied. Data adapted from Baird et al.<sup>18</sup> and unpublished sources.

**Table 2. Adjunctive primaquine therapy against falciparum and vivax malaria in the Arso region of Irian Jaya, 1992-1994.**

Infection	Regimen	Sample #	Therapeutic Failure Rate		
			7 day	14 day	28 day
<i>P. falciparum</i> ~	CQ*	38	35%	79%	92%
	CQ+PQ^	41	20%	56%	81%
<i>P. vivax</i> ~	CQ*	50	14%	44%	78%
	CQ+PQ^	78	3%	5%	9%

\* Standard chloroquine therapy of 25 mg/kg in three doses at 24 hr intervals.

^ One of three distinct regimens used:

- 1) 25mg/kg chloroquine plus 0.5 mg/kg primaquine given daily for 14 days and on alternative days up to day 28.
- 2) a single dose of 10 mg/kg chloroquine plus primaquine as in regimen #1.
- 3) chloroquine as in regimen #1 plus 1.0 mg/kg primaquine given concurrently with each of the first two doses of chloroquine followed by a 0.5 mg/kg dose with the last dose of chloroquine on day 2.

~ Data adapted from Baird et al.<sup>18</sup>.

Halofantrine has been investigated in Arso, both alone and in conjunction with standard primaquine therapy.<sup>18,19</sup> Table 3 shows the results; either regimen was highly effective against these predominantly chloroquine-resistant infections, but primaquine offered the advantage of killing liver schizonts and sterilizing any surviving gametocytes. Halofantrine is a relatively expensive anti-malarial currently protected by patent rights. It may be more than 10 years before its general use in Irian Jaya is economically practical.

In view of this, trials of combinations of antimalarials not protected by patent rights should be considered. For example, a trial of chloroquine in combination with doxycycline begins soon in Irian Jaya. If effective, this regimen could provide safe, effective and affordable therapy (although pregnant women and children would yet need some other solution). Extensive trials of standard chloroquine therapy followed by a single curative dose of Fansidar have shown great promise in the Philippines (D. Bustos, RITM,

Manila; personal communication). This practical approach to developing 'new' therapies for malaria is now being applied around the world. Many investigators recognize that costly antimalarials offer little or no immediate relief for the vast majority of people who must live with endemic malaria. Nonetheless, the development of new antimalarials, even though not immediately affordable, represents an essential step forward and a necessary investment for the future.

### Vector Control.

Where epidemic malaria occurs, mosquitoes tell the story of causality. In northeastern Irian Jaya the punctulatus group of

anophelines dominate as vectors of malaria. Multiple characteristics of these vectors combine to create extreme difficulties for vector control activities in areas like Arso.

First, there are few cattle, goats, dogs or cats in new transmigration communities; the mosquitoes, which will feed on both animals and man, focus upon the humans as targets.

Second, the mosquitoes feed both indoors and outdoors with fairly even frequency throughout the night.<sup>20-22</sup> This outdoor feeding compromises the value of mosquito nets. Even when feeding indoors, they tend not to rest on interior walls. This restricts the number of mosquitoes that can be exposed to insecticides

**Table 3. Summary of trials of halofantrine for therapy of vivax and falciparum malaria in the Arso region of Irian Jaya, 1993-1994.**

Infection	Regimen	Sample #	Therapeutic Failure Rate		
			7 day	14 day	28 day
<i>P. falciparum</i>	HF*	14	0%	0%	7%
	HF+PQ <sup>^</sup>	40	0%	0%	0%
<i>P. vivax</i>	HF*	20	0%	0%	6%
	HF+PQ <sup>^</sup>	26	0%	0%	0%

\* Standard regimen of halofantrine of three doses of 8 mg/kg given at 6 hr intervals. Data adapted from Baird et al.<sup>18</sup>

<sup>^</sup> Standard regimen of halofantrine as above, plus 0.5 mg/kg primaquine base daily for 14 days beginning the day after halofantrine. Data adapted from Fryauff and others (manuscript in preparation).

applied upon interior walls or upon mosquito netting. It may explain the results of a recent trial comparing treated to untreated bednets in Arso PIR IV: no difference in the incidence of malaria was detected between the two study groups (C. Church, unpublished).

Third, the environmental conditions in new transmigration villages create many breeding sites for the anophelines, which prefer breeding in bright, temporary pools. Areas of newly cleared rain forest are brightly sunlit, easily softened by rain, and the shallow, nutrient-rich pools created in mud by human, animal and machine traffic become increasingly exploited for anopheline breeding. These countless breeding sites in rain-filled footprints and tire ruts, usually in close proximity to homes, are often too shallow and impermanent to permit the establishment of natural predators like dragonfly larvae, tadpoles, and fish.

What can be done to attack these vectors? Education and community-based action may be the most effective weapons. Residents of transmigration villages manage virtually every square meter of their settlements with great care. Alerting residents to the danger represented by temporary sunlit pools may allow them to destroy many pools with a few turns of the hoe. Minimizing exposure to biting mosquitoes by wearing long pants and long sleeve shirts during the evening can be encouraged. Use of mosquito nets generally does not require prompting or encouragement (nets offer relief from sleep disturbed by both biting and crawling insects); the difficulty here tends to be economic, i.e., supplying and maintaining the integrity of the netting. Keeping animals like goats and cattle near the home at night may diminish the intensity of mosquitoes in the house seeking blood meals (zoophylaxis). Insecticide impregnated curtains for windows and shams for eaves may

also diminish the risk of infection within the house. Special protection for people who remain outdoors all night, like soldiers and siskamling jagas, may prevent the relatively high attack rates known to occur in these people (C. Ohrt & D.J. Fryauff, personal communication). Chemical lotions that repel mosquitoes, mosquito coils, and mandatory protective clothing may suffice. Outdoor social functions held in the evening may contribute appreciable community risk, but with judicious use of topical repellents and protective clothing, this risk could be minimized.

## SUMMARY AND RECOMMENDATIONS

Epidemic malaria is a significant problem for new transmigration communities in heavily endemic areas. Measured attack rates in the Arso region of Irian Jaya illustrate the severity of this challenge. Current strategies intended to control malaria in these communities are faced with the following challenges: 1) high rates and degrees of resistance to chloroquine and the lack of alternatives for prophylaxis or therapy, 2) limited on-site diagnostic capability, 3) the inherent difficulty of vector control due to unique feeding and breeding behaviors, and 4) the absence of a strategy which targets asymptomatic infectious carriers of disease.

New transmigrants brought to highly malarious areas merit special attention and dedication of resources. This special targeting allows attention and expenditures that may prevent epidemic malaria and greatly improve the social and economic vitality of transmigration areas. Establishing a cycle of health and economic growth (in contrast to disease and poverty) may ultimately overwhelm endemic malaria.

## TEN MEASURES TO REDUCE THE RISK OF EPIDEMIC MALARIA AMONG TRANSMIGRANTS:

1. Screen all candidate transmigrants for G-6-PD deficiency (approximately Rp.1000 per test) and provide supervised prophylaxis for three months as current policy dictates. Consider primaquine prophylaxis for non-pregnant, G-6-PD normal individuals.
2. Increased financial and administrative support for public health officers charged with the responsibility and granted the authority to command resources needed to avert epidemic malaria, specifically among newcomers. This should include the training and equipment necessary to accomplish clearly identified plans and realistic goals. These should be formulated in view of local conditions and vector bionomics.
3. Establish on-site microscopic diagnostic capability, to include monthly active case detection among all residents and eliminate asymptomatic gametocytemias for a period of six months.
4. Before the newcomers arrive, screen and treat construction teams and indigenous people who will live with them, and provide G-6-PD testing and prophylaxis to them as well.
5. Provide effective therapeutics for slide-proven malaria, eg., chloroquine (or chloroquine-primaquine for *P. vivax*, or another chloroquine combination) with careful microscopic follow-up and institution of alternative treatment in resistant cases. Include a standard two week curative regimen of primaquine with each infection regardless of species, or at least provide a single primaquine dose to prevent transmission (to be repeated along with institution of alternative therapy for those infections that recrudescence during follow-up).
6. Provide mosquito nets, curtains and shams (evidence suggests that in the case of bednets used in Arso, impregnation with insecticide provides no added benefit and may increase exposure to potentially toxic chemicals).
7. Conduct education programs on-site to inform people about mosquito vector bionomics (identify breeding sites and feeding behaviors), along with emphasizing the importance of prompt diagnosis and effective therapy of infection.
8. Organize a cadre of local volunteers trained to: a) recognize symptoms of malaria in their neighbors and encourage them to seek treatment; b) spot and eliminate mosquito breeding sites; c) understand mosquito feeding activities and personal protective measures and to encourage this in their neighbors; d) collect blood films to provide essential assistance to the local slide reader, and e) re-impregnate netting, curtains and shams as appropriate, f) work with local public health authorities in planning and implementing strategies against malaria.
9. Provide reliable motorized transport to evacuate severely sick or injured patients to hospital.
10. Offer an incentive to spur community participation in malaria control efforts, eg., a generator, television and parabola given to villages with a prevalence of malaria <10% after six months.

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