MALARIA IN HONIARA, SOLOMON ISLANDS: REASONS FOR PRESENTATION AND HUMAN AND ENVIRONMENTAL FACTORS INFLUENCING PREVALENCE

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Abstract. During February and March 1995, out-patients attending health clinics and the Central Hospital in East Honiara, Guadalcanal, Solomon Islands, were surveyed with the aim of determining factors influencing the differing rates of malaria, the proportion of transmission occurring within the town, and the reasons for presentation. Three hundred and nine adult patients, who were sick and had blood smears taken, were asked about their general knowledge of malaria transmission. Of those interviewed, 120 were visited at their home in East Honiara, to determine variables. EpiInfo 5.1 was used in analysis.

A history of fever alone was not a good indicator of parasitemia. Most precautions, including bed nets, window screens and personal precautions were of little benefit. Significant protection was afforded individuals and families with indoor kitchens. Patients not completing their antimalarial treatment fared worse in terms of parasitemia and malaria history. Most malaria/parasitemia was indigenous to Honiara. Many patients had a good knowledge of malaria transmission and mosquitos, but this did not translate into a lower rate of parasitemia or malaria.

INTRODUCTION

In the Solomon Islands, malaria has been an increasing problem in recent years. The malaria vectors in the Solomon Islands are *An. farauti* Laveran *sensu lato (s.l.)* (which in the Solomon Islands consists of three species *An. farauti s.s., An. farauti* No. 2 and No. 7), *An. punctulatus* Dönitz and *An. koliensis* Owen (Belkin, 1962; Foley *et al*, 1994).

In the 1970s, a national malaria eradication program involving DDT residual indoor spraying reduced the number of reported malaria cases to only 3,554 in 1976. The development of behavioral resistance by *An. farauti (s.l.)* to DDT (Taylor, 1975) reduced the program's effectiveness. Procurement difficulties and community resistance eventually led to its abandonment (WHO, 1992). Pyrethroid-impregnated bed net distribution, subsidised by the WHO, is one of the main strategies of the present Solomon Islands anti-malaria program (Ministry of Health and Medical Services, 1993).

Honiara, the capital of the Solomon Islands, is situated on the north coast of Guadalcanal, and has a population of over 53,000 (Ministry of Health and Medical Services, 1994). It occupies a narrow coastal strip and extends inland over low ridges and valleys. In 1992 malaria incidence in Honiara, predominantly *Plasmodium falciparum*, was 1,073 cases per 1,000 population, and remained high at 822 cases per 1,000 in 1994 (Ministry of Health and Medical Services, 1994).

Because of the seriousness of malaria in Honiara, a survey was undertaken in January to April 1995. This paper discusses the effect of various personal precautions, and the influence of some environmental and behavioral factors on malaria parasitemia in patients in Honiara. The results of a vector survey are detailed elsewhere (Bell *et al*, 1996).

MATERIALS AND METHODS

Methods

The study involved a structured questionnaire based interview of patients at health facilities and visits to the homes of some of these patients.

Sample size calculations were based on 1994 clinic data where 39.0% of 14,406 fever patients were parasitemic. A minimum number of 296 patients was required to reveal a relative risk (RR) of 2.00 with a statistical significance of 0.05 and power of 90.0%. Interviews were conducted at five clinics in East Honiara and at Central Hospital outpatients department (see figure in Bell *et al*, 1996). Selection criteria were: 1. 16 years or older, 2. non-pregnant, 3. volunteered, 4. had been resident in the study area for the preceding one to three weeks, 5. presented with illness, 6. had a blood-film taken by clinic staff.

Initially, every third patient was asked for permission for a home visit to assess factors relating to housing, environment and malaria. After two weeks, the ratio was altered to one in two. One patient refused and the next patient was substituted.

All analysis, except calculation of regression coefficients (RC), was carried out through EpiInfo 5.1 after double data entry. Probability values (p) are uncorrected unless otherwise specified. Confidence Intervals (CI) are given at the 95% level (Greenland and Robins, 1985). The malaria markers used were: parasitemia, 12 month incidence, and one month proportionate adult household malaria incidence (the proportion of > 16 year olds with a history of malaria).

Case definition

Parasitemia status was ascertained after the interviews Parasitemia combined with illness (regardless of symptoms) was the sole criterion for definition as a 'case' of malaria, for patients presenting at the clinic. Past malaria history relied on information given by the patient.

Questionnaire

The questionnaire was translated into Pijin, back translated, and pre-tested outside the study area. Complete and incomplete questionnaire results were used for analysis, if the parasitemia status and malaria history was known. If incomplete data sets had been omitted, the study would have been biased against patients with poor understanding or communication. One patient was interviewed twice on attendance for two separate illnesses: each interview was regarded as a separate record.

Constraints and limitations

P. falciparum, the main cause of malaria in the study area (Ministry of Health and Medical Services, 1994), can present with a multitude of symptoms. Parasitemia may also be incidental to patients presenting with illness (Armstrong-Schellenberg *et al*, 1994), while incidental illness may result in higher parasitemia levels. The fluctuating nature of parasite levels in patients with malarial illness may result in patients having no parasitemia at the time of their clinic attendance. Thus individual cases cannot be confirmed as a definite malarial illness, but the study examines population trends of parasitemia and illness. Past histories of malaria could not be confirmed with slide records or case notes, which were insufficient or unavailable.

Determination of location-specific malaria and parasitemia incidences was not possible due to the lack of recent population statistics for use as denominators. A bias may have been present against those who used private health care as private clinics were not included in this study. Pregnant women were excluded in order to reduce confounding due to differing immune status. Patients admitted to hospital for severe illness were not included due to difficulties of interview and follow-up. Due to the high endemicity, admission rates for adults are relatively low.

RESULTS

Demography

The mean age of the 309 patients in the study population was 28.4 years (minimum was 16 years), with a majority of males (57.9%). Numbers of adults per household ranged from 1-19 (mean = 4.77; standard deviation (SD = 2.98). Parasitemia was present in 125 patients (40.5%), 95 (76.0%) with *P. falciparum*, and 30 (24.0%) with *P. vivax*.

Including the present episode, when parasite positive, the mean number of episodes of malaria in the last 12 months was 3.99 (SD = 4.01, range 0-25, median 3), 49 (15.9%) individuals having been malaria free. In the month prior to interview the mean proportion of adults who had a history of malaria in the 309 patients' households was 0.35. Seventy-six (24.6%) households had been malaria free.

Table 1

Personal protective measures, malaria parasitemia and 12 month malaria incidence amongst patients in East Honiara from whom a blood film was taken.

Type	No. of users	Parasitemia (%)	Mean 12 mth incidence
'Moretein' spray	17	17.6	3.24
Preventive medication	19	21.1	3.24
Skin repellent	26	34.6	4.46
Long pants	47	36.2	3.55
Mosquito coils	91	36.3	4.21
Footwear	38	39.5	4.37
'Mosba' soap	32	10.6	5.38
Custom medicine	55	13.6	4.35

Parasitemia rates were significantly higher amongst males (RR 1.49, confidence interval (CI) 1.11-2.00, p = 0.007) with no significant variations with age or education. Parasitemia varied between suburbs, from Betikama (48.5%) and Kombito (53.3%), to Naha (25.0%), Kukum (26.9%) and Fishing Village (26.7%). Patients' parasitemia rates were similar in the 76 households with a history of malaria (41.3%), and the 49 with no history of malaria (39.2%) in the past month. The 18 patients living more than 60 minutes from a clinic had a higher RR of parasitemia compared to patients who travelled less than an hour (1.41, p = 0.18), and higher mean 12 month malaria incidence (4.01 to 2.50, analysis of variance (ANOVA) p = 0.54).

Recent travel

Only 86 of 308 patients had spent at least one night away from home in the last 1-3 weeks, mostly elsewhere within Honiara (parasitemia rate 37.0%). The 23 who had stayed elsewhere on Guadalcanal and the 15 on other islands had parasitemia rates of 47.8% and 26.7%, respectively, while the rate amongst those who had not travelled was 41.4%. None of these differences achieved statistical significance.

Personal habits and precautions

Patients were asked 9 questions about personal protection against mosquitos and malaria, including the use of prophylactic medicine, custom (traditional) medicine, proprietary skin repellents, a local repellent soap ('Mosba'), mosquito coils, the use of long pants and footwear in the evenings, and other precautions specified by the patients. Custom medicine frequently consisted of pawpaw leaves or tree bark. The results are shown in Table 1. Those who took prophylactic medicine (19) were 0.50 as likely to have parasitemia as others (p = 0.08) and had malaria less often in the past year, (ANOVA p = 0.53). The use of "mortein" spray by 17 patients was significantly protective for parasitemia (RR parasitemia 0.42, p = 0.05; mean malaria incidence 3.24, ANOVA p = 0.56; mean household one month malaria incidence 0.35, ANOVA p = 0.95). No other methods provided significant benefit, custom medicine and Mosba soap users having both parasitemia rates and 12 months malaria incidences non-significantly above the mean.

Bed nets

Bed nets were 'always' used by 91 (29.5%) of 308 patients, and 42.9% of these nets were impregnated, 25 within the last 12 months. A parasitemia rate of 37.4% (RR 0.90, p = 0.51) was recorded in the 91 patients who always slept under bed nets, 41.6% in those who never slept under them, and 41.1% in those with nets treated within 12 months (Table 2). The mean 12 month malaria incidence of those who always used bed nets was 4.39, and marginally lower (4.12) if the bed net was treated within 12 months. A higher proportion of females slept under bed nets (39%) than males (33.8%). Overall bed net use differed only marginally with

Table 2

Bed net use and malaria parasitemia amongst patients in East Honiara from whom a blood film was taken.

	Patient numbers	Parasitemia rate (%)
All patients	309	40.5
Always use net	91	37.4
Always use impregnated net	39	37.5
Always use impregnated net < 12 mo	25	41.1
Never use net	134	41.6

Table 3

Relation of parasitemia rates and malaria incidence with kitchen type amongst patients in East Honiara from whom a blood film was taken.

	Indoor kitchen		Outdoor kitchen	
	Parasitemia (%)	12 mo malaria incidence	Parasitemia (%)	12 mo malaria incidence
All patients	29.3	3.34	50.6	4.79
Females	20.0	2.75	51.9	7.26
Males	38.1	3.50	50.0	3.91

education level. Only 3 patients did not know where to buy bed nets. The main reasons for not using nets were lack of money and the hot climate.

House types and location

All 309 patients were asked at the clinics whether their houses were screened, and how close they lived to creeks or swamps. Further information was provided on 120 patients (52 with parasitemia, 68 without), through visits to 112 homes. Variables were compared with parasitemia rates, mean 12 month and 1 month household malaria incidence, and the RR of > 3 malaria episodes in the past 12 months and > 1 household malaria episodes in the past month.

The houses of 37 (30.8%) patients had adequately screened windows. No relationship between the presence or absence of screens and parasitemia rates or malaria incidences were found, the crude RR of parasitemia in patients from screened homes being 0.99 (p = 0.99) Adjusting for kitchen site (see below) resulted in a RR of 1.28 (p = 0.59).

Kitchens were indoors in 34.2% of houses, while most outside kitchens were of open leaf construction. Relationships with parasitemia and malaria incidence are shown in Table 3.

Patients with indoor kitchens recorded significantly lower parasitemia rates (RR 0.58, CI 0.34-0.98, p = 0.03), and fewer households had a case of malaria within the previous month (RR 0.74, CI 0.57-0.97, p = 0.01). These trends were more marked amongst females, with rates of parasitemia and > 3 episodes of malaria in 12 months being significantly lower (RR 0.39, CI 0.15-1.00, p = 0.03; RR 0.42, CI 0.19-0.96, p = 0.02 respectively). Rates were also lower among males but not reaching statistical significance (RR 0.76, p = 0.56; RR 0.82, p = 0.73, respectively). The protective effect of indoor kitchens remained when allowing for confounding due to differing frequencies of malaria and kitchen placement in different suburbs (summary RR 0.35, CI 0.23-0.11, p = 0.03; summary RR 0.52, CI 0.22-0.98, p = 0.18; summary RR 0.63, CI 0.40-0.87, p = 0.04 for parasitemia > 3 mal/patient-year and 1 + mal/household-month respectively).

Table 4

Frequency of parasitemia and presenting symptoms amongst patients in East Honiara from whom a blood film was taken.

	% of patients	% of parasitemia
Headache	64.8	42.9
Cold	28.4	34.8
Body pain	17.3	32.1
Cough	13.6	45.5
Back pain	9.9	56.3
Malaria	26.2	44.4
Fever	21.4	42.4

Elevation of houses on stilts > 1.5 m, the presence of indoor toilets and water supply, and the presence of dogs or pigs close by had no significant impact on malaria incidence. Non-significantly lower rates associated with indoor water and toilets were lost when their association with indoor kitchens was taken into account. Most houses were constructed of wood or fibro-cement sheet, with iron roofs, others having concrete, leaf or iron walls, some with leaf floors. There were no significant associations between construction materials and parasitemia or malaria rates.

Symptoms and treatment

'Malaria' was mentioned as a reason for presentation by 81 patients (26.2%), 'fever' by 66 (21.4%), and 'other symptoms' by 162 (52.4%) (Fig 4). Only 28.8% of women with 'other symptoms' had parasitemia, compared with 46.3% of men (RR 0.62, CI 0.41-0.94, p = 0.02). 'Headache' was the primary complaint amongst those with 'other symptoms' and mentioned alone or with other symptoms by 105 (64.8%). It was most strongly associated with parasitemia (42.9%), (RR 1.53 compared to other symptoms, p = 0.06). Back pain and cough were non-significantly associated with parasitemia (Table 4). A higher proportion of patients who had *P. falciparum* parasitemia presented with 'other' symptoms (51.6%), then those with *P. vivax* (40.0%), p = 0.13.

Compliance: Of 253 patients with a history of treatment, 32 (12.6%) reported failure to finish their course of drugs. These patients had a 47% higher mean number of episodes of malaria in the past year (6.38, Mann-Whitney 2-tailed test p = 0.0005), and a RR of 1.48 of having parasitemia (CI 1.05-2.09, p = 0.04).

Malaria knowledge

Most patients were asked 2 questions concerning the causes of malaria and mosquito habitats. The unprompted answers of 239 (77.3%) of 300 patients to the first question were considered correct ('mosquito parasites', 'anopheline mosquitos', 'female mosquito', or 'mosquitos', including exposure due to lack of nets). Of 309 patients, 278 (90%) could name mosquito habitats correctly and 74.1% mentioned potential anopheline habitats (such as shallow pools, ditches, streams). Good knowledge was non-significantly associated with a higher level of school education. Parasitemia rates were not significantly higher in those with poor knowledge of malaria (RR 1.08, p = 0.65).

Bed nets were 'always' used by 30.3% of those with good knowledge of causes of malaria, 23.0% of those with poor knowledge (p = 0.23), although they were less likely to have screened houses (28.0% compared to 41.2%, p = 0.31). Prophylactic medicine was only taken by those with good knowledge of malaria (18 patients, p = 0.03).

DISCUSSION

The study involved a subset of the Honiara population, those attending clinics for illness and having a blood film taken. This partly explains the high levels of parasitemia. Their high reported malaria incidence may reflect greater that average exposure or susceptibility or be representative of Honiara residents. Results are specific to this group, but general trends should be attributable to the population as a whole. Socio-economic status was not assessed, as monetary income and/or visible assets are poor indicators in the social milieu of Honiara. Parasitemia and malaria variations between suburbs (low in both seemingly affluent Naha and the apparently poorer Fishing Village) suggest that economic well being is not a major determinant.

Relatively few patients had spent a night outside the town limits in the previous 1-3 weeks, and the lower overall parasitemia rate amongst these people indicate that most infection is occurring within Honiara.

Prophylactic medicine and 'mortein' (insecticide) spray were the only methods of personal protection against malaria which were significantly effective. The latter was protective of the user but not the household, suggesting it may be used as a topical repellent. Long-term prophylaxis could not be recommended for residents. The lack of success of other methods may be related to an intrinsic lack of effect, or inadequate usage patterns which may be related to the poor economic status of many residents, and the climate (too hot for footwear and long pants).

The ineffectiveness of bed nets is in contrast to the results of studies elsewhere by Bradley *et al* (1986), Snow *et al* (1988) in The Gambia, and Charlwood and Graves (1987) with *An. farauti s.l.* in PNG. Previous studies in the Solomon Islands have suggested a lack of efficacy, particularly in the presence of *An. farauti s.l.* (Hii *et al*, 1993; Bakote'e and Arabola, 1992; Japanese International Cooperative Association, 1995). Kere *et al* (1993) indicated a potential benefit, but in a rural setting some distance from Honiara. As with window screening, the lack of benefit due to bed nets in this study can be attributed to the exophagic crepuscular behavior of the principle vector *An. farauti* No. 1. In the crowded conditions and hot climate, most residents spend the evenings outdoors. Bed nets offer more protection against childhood malaria (not assessed in this study), as children tend to sleep earlier. Bed nets have been more effective against *An. punctulatus* (Bakote'e and Arabola, 1992), and the reappearance of this vector in Honiara (Bell *et al*, 1996) while still rare, suggests bed nets may become more important in the future.

The exophagy of *An. farauti* also explains the lack of influence of type of house construction where materials allowing freer vector passage have not resulted in higher malaria rates. Indoor kitchens were clearly of benefit to women (the principle cooks) by keeping them indoors during the peak biting time of *An. farauti* s.l. (Taylor, 1975). Males of these households had a lesser benefit although they probably ate indoors and so received some protection. Outdoor kitchens are generally of open leaf construction, and women who have to work in these are the most at-risk group.

Elevation of houses on stilts offered no protection. The presence of dogs and pigs, both bloodmeal sources for *An. punctulatus* complex members (Burkot *et al*, 1988), neither raised nor lowered local malaria rates, perhaps because both humans and dogs are highly mobile in the town in the evening.

The wide range of symptoms, particularly associated with *P. falciparum*, emphasises the difficulty in obtaining a correct diagnosis and deciding who should be treated. The results suggest that headache and possibly back pain, rather than fever alone, can be indications for treatment. Non-specific symptoms due to *P. falciparum* have been reported previously (Armstrong-Schellenberg *et al*, 1994; Smith *et al*, 1995).

The high level of knowledge of malaria causation and mosquito habitats provides a good basis for further education. However, at present those with good knowledge are not deriving increased protection against malarial illness. This is likely to be due to the poor effectiveness of bed nets and other frequently used methods of protection, and general poor association between good knowledge and the use of precautions. Clearly, emphasis by education campaigns on the biting habits of *An. farauti* No. 1, and the importance of staying indoors in the evenings, will at least allow people to choose an effective means of protecting themselves, although the hot climate and the necessity for most women to cook outdoors will probably result in few following this advice.

CONCLUSIONS

This study leaves little doubt that the bulk of malaria in Honiara is acquired within the confines of the town and that avoidance of vector contact by remaining indoors in the early evening is an effective way of reducing malaria incidence. Bed nets, screens and most personal precautions are not significantly protective for the adult population. Community knowledge is high but offers little advantage at present and education programs need to take into account the specific biting behavior of *An. farauti* s.l.

The importance of compliance with drug treatment needs to be stressed, and if mild to moderate cases of malaria are to be treated, the criteria for taking blood films may need to be wider than fever alone.

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