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Original article

Knowledge, Attitudes and Practices Relevant to Malaria Control in Remote Island Populations of Manus, Papua New Guinea

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Abstract: A community-based cross-sectional survey of 262 participants in four island communities of Manus, Papua New Guinea was conducted using a structured questionnaire to examine possible factors of malaria prevalence, including education experiences, knowledge, attitudes, and preventive behaviors, in relation to antimalarial antibody titers. Bivariate and multivariate analyses revealed that micro-environmental conditions caused inter-community differences in malaria prevalence. Ninety-nine percent of the subject villagers recognized mosquito bites as a cause of malaria transmission, which explains the high possession rate of bednets. There was a significant correlation between malaria education experience at schools and knowledge ($p < 0.01$) and between knowledge and bednet use ($p < 0.05$). However, regular bednet users were only 35% of the total, due primarily to feelings of discomfort, heat, and stuffiness inside the bednet. Villagers' behavior of consulting an aid post orderly (APO) in case of high fever significantly lowered the titer level ($p < 0.05$), while their bednet use did not. This unexpected result was attributable to inappropriate bednet use and to daily living patterns, including both subsistence and social activities. We conclude that information regarding lifestyles and attitudes toward bednet use as well as malaria education experience at schools are particularly important for practical malaria prevention.
Key words: bednet, education, knowledge, malaria, Papua New Guinea, preventive behavior

INTRODUCTION

The current strategic approaches to malaria control emphasize prevention through the use of insecticide-treated bednets (ITNs). The World Health Organization (WHO) reported that, by the end of 2010, approximately 289 million ITNs would be delivered to sub-Saharan Africa, enough to cover 76% of the persons at risk of malaria, and that these preventive efforts, together with other approaches such as indoor residual spraying, would contribute to the continuous decline of malaria cases and deaths in Africa in particular [1]. However, many countries, including Papua New Guinea (PNG) in the WHO Western Pacific Region, remain in a precarious situation [1, 2].

Malaria has long been one of the most serious life-threatening diseases in PNG, causing high morbidity and mortality [2]. Since 2004, the Global Fund to Fight AIDS, Tuberculosis and Malaria (GFATM) has provided financial support, covering more than half of the disbursement devoted to anti-malaria programs in this country [3]. Nonetheless, a large proportion of the expenditure has been used for diagnostics, and the coverage of ITN remains far below the target level [4]. Systematic reviews confirm the effectiveness of ITN use in reducing the risk of malaria morbidity and mortality, although the ownership of an ITN is not necessarily synonymous with its utilization [5]. In other words, not only the inadequate supply but also the improper use of ITNs tends to undermine the preventive effect against malaria. Since the way in which household decision-making affects malaria prevention is poorly understood [6], it is crucial to identify the factors determining people's knowledge, attitudes, actions, and relationships, taking malaria prevalence into account.

Based on fieldwork conducted in remote island communities in PNG, this paper aims to examine what factors have contributed to a reduction in antimalarial antibody titers by analyzing various factors such as education experiences, knowledge, individual preventive behavior, and communal behavior directed at reducing mosquitoes, and to seek effective ways to promote malaria prevention in the study area and beyond.

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MATERIALS AND METHODS

Study area and subjects

Fieldwork was undertaken in the Balopa area, located 40 km southeast of the main islands (Manus and Los Negros) of Manus Province, one of the remotest provinces in PNG. The climate of this area is typical of the South Pacific region with little seasonal fluctuation due to the tropical insular environment. Balopa area constitutes three small islands, i.e. Baluan, Pam, and Lou, all of which are mostly covered by primary rainforest and secondary forest. There are 13 communities in the three islands. The inhabitants in one community, called Mouk, on Baluan depend on fishing and trading for their livelihood while those in others subsist mainly on slash-and-burn cultivation and small-scale fishing. No water supply or electricity is available on these islands, and the people collect rain for drinking water and use kerosene lanterns for lighting. The geographical, environmental, and ethnological characteristics of Balopa have been described elsewhere [7–9].

Four Balopa villages were selected for this study: Solang in Lou Island, Ngambaoi in Pam Island, and Perelik and Mouk in Baluan Island. They were also the targets in our previous report on malaria prevalence [9]. Among the four villages, accessibility to the nearest aid post (AP) did not markedly differ, being within 15 minutes on foot. Each AP provides villagers with health services, including antimalarial drugs such as chloroquine, free of charge. The main malaria vector in this area was judged to be *Anopheles farauti* s.s. (No. 1), a sibling species that breeds in brackish water. Antimalarial antibody titer level (either *Plasmodium falciparum* or *P. vivax*, or both) detected by the indirect fluorescent antibody test (IFAT), which persists for at least six months [10], was highest in Mouk, followed by Solang, Perelik, and Ngambaoi [9].

Verbal consent was obtained and interviews were conducted after blood sampling in the four villages. The time allocation survey by means of direct observation was conducted for Perelik and Mouk villagers to explore the time spent at locations high at risk for mosquito bites in daily life. The number of subjects, including males and females ranging in age from 14 to 79 years, was 197 for blood sampling (for details, see [9]), 262 for interview survey, and 164 (in two villages) for time allocation survey. The participation rate to the interview survey ranged from 75 to 100% in the four villages; most villagers who did not participate were temporarily absent. This study was conducted with the approval of the Medical Research Advisory Committee of Papua New Guinea.

Data collection and analytical framework

The interview survey, based on a 60-item structured questionnaire focusing on education experiences, knowledge, attitudes, and practices against malaria, was conducted in the local vernacular (Table 1). The villagers' answers about bednets, dwelling houses including windows, and water containers/reservoirs were confirmed during the authors' visit to each household. For the time allocation survey, an "observation at fixed spot" method and a modified "spot-check" method [11] were combined. For 14 consecutive days, one of the authors (YA) and local assistants recorded the location frequented by each villager, once every hour from 6:00 to 20:00 in Perelik and from 6:00 to

Table 1. Items involved in the questionnaire [the number of smaller items for each item]

Individual characteristics	
Age, sex, and ethnicity	[3]
Subsistence activity (occupation)	[1]
Educational level	[1]
Educational experience at schools regarding malaria	[**3**][a]
Educational experience at health facilities regarding malaria	[**4**][b]
Knowledge of malaria etiology and symptoms	[**10**][c]
Recognition of mosquito variety and ecology	[7]
Possession, type and frequency of bednet use	[**3**][d]
Reason(s) for no/irregular use of bednets	[1]
Other individual preventive behavior for malaria	[14]
Details of past malaria infection: frequency, treatment and side effects	[4]
Treatment-seeking behavior when suspecting malaria	[**1**][e]
Household characteristics	
Village	[1]
Household's subsistence activities	[1]
Type of water container/reservoir around the house	[1]
Behavior: removal of water around the house	[**1**][f]
Behavior: extermination of mosquito larvae	[**1**][f]
Behavior: cutting grass and cleaning around/inside the house	[**1**][f]
Structure of the house: wall, roof, floor, doors and windows	[2]

Note: Figures of bold letters are the variables used for CMH statistical analysis.
[a] Corresponding to the "education at schools" variable.
[b] Corresponding to the "education at health facilities" variable.
[c] Corresponding to the "knowledge" score variable, based on eight smaller items for the causes and two smaller items for the symptoms.
[d] Corresponding to the "bednet use" variable.
[e] Corresponding to the "consultation with APO" variable.
[f] Each corresponding to the variable for communal behaviors for "reducing mosquitoes."

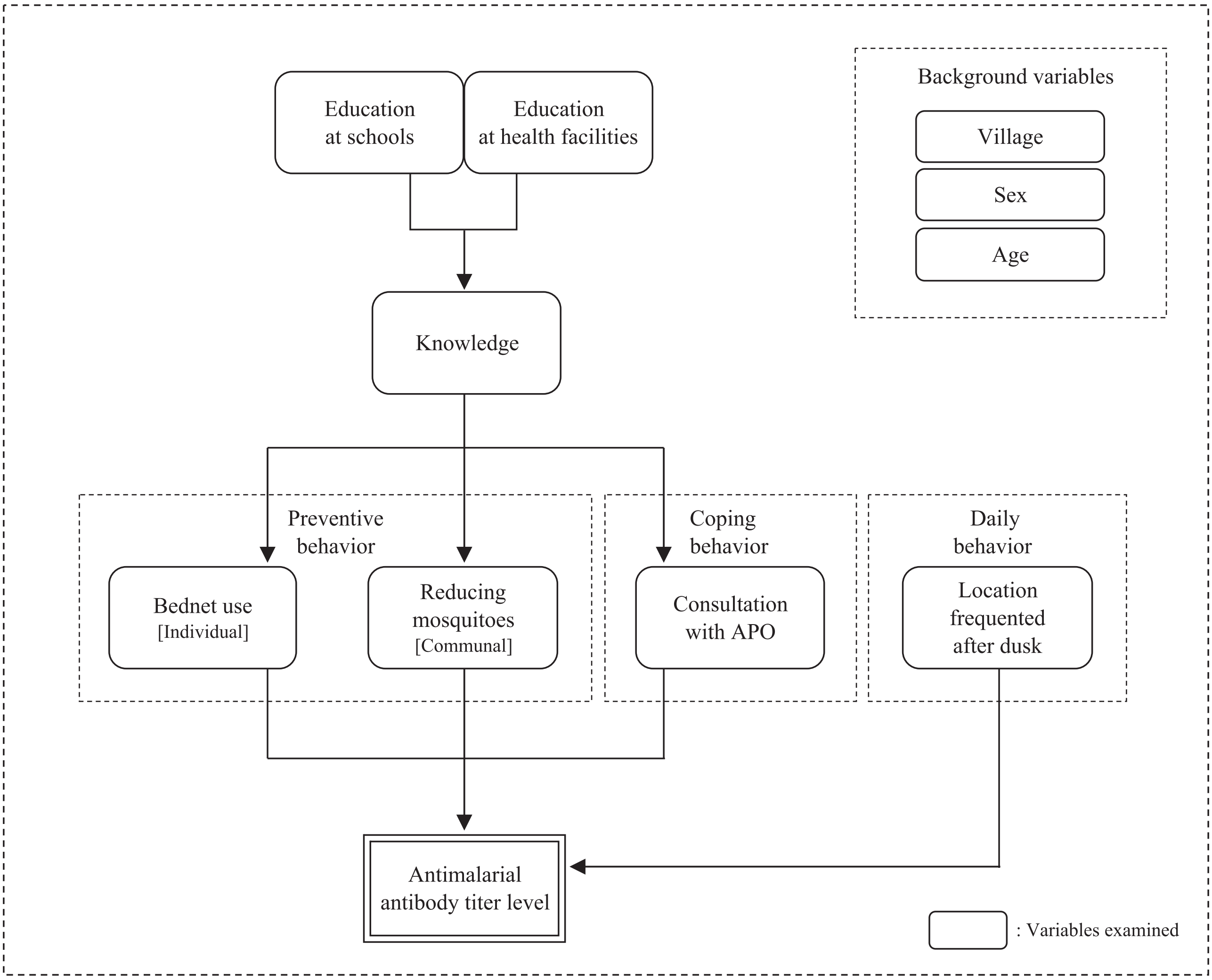

Fig. 1. Schematic diagram of the analytical model of factors related to antimalarial antibody titer level.

19:00 in Mouk (where the authors' visits after 19:00 were not approved).

An analytical model of this study was prepared on the basis of the number of reported findings. As shown in Figure 1, this model involves individual (each person's) preventive behavior, particularly "bednet use" [12, 13], communal preventive behavior for "reducing mosquitoes" [14, 15], individual coping behavior such as "consultation with aid post orderly (APO)" [16–18], and individual risk avoidance behavior to prevent mosquito bites by moving away from the "high-risk location after dusk" [19]. The model assumes that three variables, i.e. "bednet use," "reducing mosquitoes," and "consultation with APO," are determined by an individual's knowledge of malaria [20–23], which, in turn, is conditioned by his/her education experiences regarding malaria [24–26]. The education experiences were divided into two categories in this study because the villagers had opportunities to receive two different types of malaria education, one in elementary or secondary schools, and the other at the village aid post (AP) or in other health facilities during their visits for treatment and/or consultation.

In the analysis, the causal effects of various factors were examined according to the flow chart shown in Figure 1. Based on the antimalarial antibody titer level reported in our previous paper [9], the subjects were divided into high-titer (>1:1024) and low-titer (≤1:1024) groups. Twenty-four questionnaire items judged to be relevant to malaria prevention and/or malaria titer level were used as independent (explanatory) variables to determine the dichotomized groups (dependent variables). For instance, the malaria education experience at schools and that by APO or by means of brochure and/or posters was called "education at schools" and "education at health facilities," respectively. The latter included cases in which the villagers learned about malaria from the provincial health staff at the mobile clinic, which was usually held once a month on each island. As an indicator of knowledge of malaria, or "knowledge score," the sum of correct answers to 10 questionnaire items (eight for causes and two for symptoms) was used. In determining the factor of "bednet use" as an individual preventive behavior, the use of flywire screens on all windows was included. With regard to the communal preventive behaviors for reducing mosquitoes, "removal of water around the house," "extermination of mosquito larvae," and "cutting grass and cleaning around/inside the house" were used. The villagers were divided into two groups: those who did at least one of the three behaviors and those who did none at all. In the time allocation survey, the proportion of each villager's time spent in "four categorized zones after dusk" was analyzed as a factor of malarial risk on the basis of the assumption that *Anopheles farauti* is active in the evening [27, 28].

Statistical analysis

Comparisons between the low-titer and high-titer groups were made by chi-square test for bivariate analysis. Crude odds ratios (OR) and their 95% confidence intervals (95% CI) were calculated. Multivariate analysis using the variables, which were significantly related in the bivariate analysis, was performed by conditional logistic regression. To evaluate the association between the variables under control of other variables, Cochran-Mantel-Haenszel (CMH) statistics were computed for each pair. In this analysis, the knowledge score was treated as a continuous variable. All statistical analyses were conducted using the SAS statistical package (SAS 9.2, SAS Institute Inc., Cary, NC).

RESULTS

Almost all villagers recognized mosquito bites as the cause of malaria (99%), but there were several incorrect answers, e.g. drinking water (contaminated with mosquito

Table 2. Estimated odds ratios for malaria-related variables by bivariate and multivariate analyses

Variable	Titer group		Odds ratio			
	High	Low	Crude odds[b]	p	Adjusted odds	p
Consultation with APO in case of high fever[a]						
Yes	1 (2%)	16 (25%)	0.054 (0.007–0.426)	0.006	0.011 (0.001–0.226)	0.003
No	54 (98%)	47 (75%)	1.000			
Belief of "eating something bad is a cause of malaria"						
Yes	14 (64%)	27 (76%)	0.455 (0.208–0.999)	0.050	0.224 (0.072–0.695)	0.010
No	41 (36%)	36 (24%)	1.000			
Abundance of mosquitoes						
Many	41 (75%)	15 (24%)	14.760 (4.803–45.358)	<0.001	–	–
Not many-moderate	9 (16%)	21 (33%)	2.314 (0.674–7.942)	0.182	–	–
None-very few	5 (9%)	27 (43%)	1.000			
Open window between dusk and dawn						
Yes	34 (62%)	55 (87%)	0.235 (0.094–0.591)	0.002	–	–
No	21 (38%)	8 (13%)	1.000			
Use male flower spike of breadfruit as mosquito repellent						
Yes	9 (16%)	2 (3%)	5.967 (1.230–28.950)	0.027	–	–
No	46 (84%)	61 (97%)	1.000			
Assume "keep himself/herself clean" as a preventive behavior						
Yes	1 (2%)	9 (14%)	0.111 (0.014–0.907)	0.040	–	–
No	54 (98%)	54 (86%)	1.000			
Village[a]						<0.001[c]
Mouk	29 (53%)	2 (3%)	78.300 (13.999–437.950)	<0.001	208.240 (20.463–2119.104)	<0.001
Solang	12 (22%)	13 (21%)	4.985 (1.449–17.146)	0.011	5.097 (1.361–19.087)	0.016
Perelik	9 (16%)	21 (33%)	2.314 (0.674–7.942)	0.182	4.676 (1.164–18.789)	0.030
Ngambaoi	5 (9%)	27 (43%)	1.000			

[a] These two variables were included in Figure 1 as "consultation with APO" and "village," respectively.
[b] 95% confidence interval in parentheses.
[c] *P* value for overall "village" variable.

eggs) (24%). Eighty-two percent of the villagers understood that the worm-like creatures, i.e. mosquito larvae, in water were related to mosquitoes. In response to the questions on diurnal biting cycles of mosquitoes, many villagers answered that the cycle differed between malaria transmitting species and non-transmitting species. The villagers, except those from Mouk, recognized that the biting time of the former occurred from dusk to dawn while that of the latter showed no clear peak.

Of the 262 subjects, 56% and 60% had education experience at schools and health facilities, respectively. The mean knowledge score was 5.6 (SD: 2.2), with significant differences among the four villages ($p < 0.001$). Among the subject villagers, 76% owned a bednet, 6% shared a bednet with other household members, and 18% had none, while only nine villagers owned an insecticide-impregnated bednet. Thus, the possible bednet users reached 82% of the total, but the questionnaire revealed that regular users, including users of flywire screens, accounted for only 35%. Three kinds of behavior for reducing mosquitoes were adopted by 104 villagers: "cutting grass and cleaning around/inside the house" was the most frequent (26%), followed by "removal of water around the house" (19%), and "extermination of mosquito larvae" by means of pouring hot water or one to two drops of kerosene onto the water surface (12%). With regard to coping behaviors, two-thirds of the subjects (68%) visited health facilities for treatment when they thought they might be suffering from malaria. Among the remaining 84 villagers, 67% conducted self-treatment with antimalarial drugs and 33% used traditional methods of questionable value.

Table 2 shows the variables, which differed significantly between the high- and low-titer groups after both bivariate and multivariate analyses. A significantly lower proportion of high-titer group (2%) than low-titer group (25%) subjects was found in consultation about high fever with APO (OR: 0.011, 95% CI: 0.001–0.226; $p = 0.003$). The belief that "eating something bad is a cause of malaria" also significantly differed (OR: 0.224, 95% CI: 0.072–0.695; $p = 0.010$). The "village" variable showed a highly significant association with dichotomization into the two titer groups. It is noted here that neither bednet use as an individual preventive behavior nor efforts for reducing mosquitoes as communal preventive behaviors differed between the titer groups in the bivariate analysis.

CMH statistics for each pair of variables were calculated for all the villagers pooled and for villagers in each village (Table 3). For all villagers pooled, a significantly positive association was found between education at schools and knowledge ($p = 0.002$), between knowledge and bednet use ($p = 0.018$), and between consultation with APO and titer group ($p = 0.006$), while a significantly negative association was found between education at health facilities and knowledge ($p = 0.020$). It is noted again that there was no significant association between bednet use or behaviors for reducing mosquitoes and the titer groups.

Table 4 shows the significant inter-village differences in bednet use revealed by chi-square test: Solang, Mouk, Perelik, and Ngambaoi in decreasing order of proportion of regular use. As to the reasons for no/irregular use, 83 (53%) of the 156 villagers able to use bednets attributed it to feelings of discomfort, heat, and stuffiness inside the bednet. The remaining villagers' answers were "low/no mosquito density" (33%, 51/156) and "sufficient prevention (owing to other preventive methods)" (14%, 22/156). The former was particularly common among Ngambaoi villagers.

The locations frequented by the villagers were categorized into four zones, i.e. "out-of-village" (mostly, gardens), "sea" (mostly, for fishing or travel by canoe), "village" (outside the house), and "house." The proportion of time spent in these zones by Perelik and Mouk villagers in the evening were compared between the high-titer and low-titer groups.

Table 3. CMH values for pairs of malaria-related variables, when village, sex and age are controlled

Subjects	Education at schools	Education at health facilities	Knowledge vs.			Bednet use	Reducing mosquitoes	Consultation with APO
	vs. Knowledge		Bednet use	Reducing mosquitoes	Consultation with APO	vs. Malaria titer level		
All subjects[a]	9.650 (+)[b]**	5.410 (–)*	5.626 (+)*	0.454	0.068	0.140	2.576	7.653 (+)**
Mouk	6.730 (+)**	5.860 (–)*	6.826 (+)**	2.025	1.466	2.177	1.726	7.000 (+)**
Solang	1.346	0.050	0.583	0.353	–	0.600	3.100	–
Perelik	5.733 (+)*	4.787 (–)*	0.032	0.141	0.025	0.122	0.213	3.446
Ngambaoi	0.388	0.403	0.558	0.695	0.601	0.895	2.500	1.263

[a] Village variable was controlled only for the case of "all subjects."
[b] (+): the higher one variable the higher the other; and (–): the higher one variable the lower the other.
* Significance of association, $p < 0.05$.
** Significance of association, $p < 0.01$.

Table 4. Frequency of three bednet use categories and the reasons for no/irregular use of bednets

Village	Bednet use	N	Regular use[a]	Reasons for no/irregular use of bednets			
				Discomfort	Low/no mosquito density	Sufficient prevention	No bednet
Mouk	Regular use	7	7	–	–	–	–
	Irregular use	47	–	29	17	1	–
	No use	28	–	5	0	4	19
Solang	Regular use	47	47	–	–	–	–
	Irregular use	5	–	0	2	3	–
	No use	16	–	0	0	14	2
Perelik	Regular use	4	4	–	–	–	–
	Irregular use	47	–	39	8	0	–
	No use	17	–	4	2	0	11
Ngambaoi	Regular use	1	1	–	–	–	–
	Irregular use	19	–	6	13	0	–
	No use	24	–	0	9	0	15
All villages	Regular use	59	59	–	–	–	–
	Irregular use	118	–	74	40	4	–
	No use	85	–	9	11	18	47
Total		262	59	83	51	22	47

[a] The numbers were based on the bednet use only, excluding use of flywire screens.

From 18:00 to 19:00, approximately 20% of Perelik villagers were still out of the village, while most others stayed in the village (63%) or in the house (14%). From 19:00 to 20:00, the percentage of villagers in the house increased to 28% but that in the village was still 66%. The comparison between the two titer groups showed no significant difference among the four zones ($\chi^2 = 1.531$, $p = 0.675$). Approximately 30% of Mouk villagers (whose data was available only from 18:00 to 19:00) stayed in the house, 8% at the sea, and the remainder in the village. There was a significant difference in the proportion of time spent in each zone between the two titer groups ($\chi^2 = 6.507$, $p = 0.039$), although the inter-group comparison had little meaning due to the small number of low-titer group subjects in Mouk (N = 3). A more important finding was that no one in either village used a bednet in the house during the observation time (18:00–20:00 for Perelik and 18:00–19:00 for Mouk) throughout the time allocation survey.

DISCUSSION

This study demonstrated that people's behaviors and environmental factors significantly influence malaria intensity in remote island communities in PNG. Of the three associations revealed by the multivariate analysis, the significant effect of "village" on the titer level was consistent with our previous finding that geomorphological and geophysical conditions primarily determined inter-village variation of malaria intensity through differences in mosquito density [9]. The significant effect of "consultation with APO" was understandable simply because the villagers were likely to seek assistance when they suffered from malaria. Regarding the effect of "eating something bad is a cause of malaria," the causal relation was less clear, although it is possible that the villagers with high titer levels tended to worry about questionable risks such as the intake of unfamiliar foods.

The analyses under control of other factors, including "village," proved the accepted formula for malaria prevention, represented by a significant correlation between education experience at schools and knowledge and between knowledge and bednet use. It is safe to assume that education experience at schools played an important role in increasing bednet use through enhanced knowledge regarding malaria.

Contrary to our expectations, however, bednet use was not associated with the two titer groups. The bednets used by most Balopa villagers were not ITN type but made of cotton, although one reviewer concluded that untreated bednets provide a protective effect against malaria when appropriately used [13]. There were two plausible reasons for the lack of an association. First, the villagers tended not to use bednets when (and where) annoying mosquitoes were few in number. For instance, the villagers of Ngambaoi on Pam Island, where mosquito density was markedly low, used bednets infrequently. Second, cotton-made bednets elicited strong feelings of discomfort, like hotness and stuffiness, prompting the villagers to put them aside.

Another explanation for the non-significant association between bednet use and malaria titer level came from the time allocation study, which revealed that all subject villagers, even those who used bednets regularly, were outside the bednets from 18:00 to 20:00, i.e. the active biting time of *An. farauti*. For many villagers, this time period is important not only for domestic work but also for various social activities. It is not easy, therefore, to reduce this risk, even though many villagers recognized the danger of mosquito bites in this time zone.

The villagers' knowledge about malaria, including recognition of larvae in water as a risk factor, is judged adequate. However, this knowledge rarely triggered communal preventive behaviors. In fact, "removal of water around the house" and "extermination of mosquito larvae" were seldom conducted. The villagers were more likely to conduct "cutting grass and cleaning around/inside the house," but this behavior is recognized by villagers as a customary obligation, irrespective of their education experiences regarding malaria. From a cost-benefit viewpoint, these communal preventive behaviors differ markedly from individual-based bednet use, which requires little time and energy but directly benefits the user by reducing malaria risk and also by eliminating the nuisance of mosquitoes during sleep [29, 30].

Interestingly, the relationship between knowledge and the two types of education showed opposite effects. The positive correlation between education at schools and knowledge seems reasonable. On the other hand, the negative correlation between education at health facilities and knowledge may have stemmed from the fact that elderly villagers, who seldom had an opportunity to attend elementary or secondary school, were more likely to receive this type of education. In addition, education at schools treats a wide range of subjects regarding malaria while that in health facilities tends to focus on treatment itself. Although the role of education at health facilities in malaria prevention cannot be denied, this study suggests that malaria education at schools plays a more important and effective role.

The insignificant effect of bednet use and communal behavior for reducing mosquitoes exerted on the villagers' titer levels is significant in considering practical ways to implement malaria prevention measures. In view of the finding that villagers did not stay inside a bednet during the biting time of *Anopheles* mosquitoes, it is advisable to urge them to wear long-sleeved shirts and long trousers in the evening hours. The introduction of insecticide-impregnated bednets or curtains, which effectively kill mosquitoes and keep them away from dwellings [12, 31–33] and also make the users less uncomfortable, is another possible means for reducing mosquito bites, although it may be necessary to consider the issue of cost.

From the viewpoint of primary health care, the increase of time spent on communal behaviors for reducing mosquitoes should be given precedence simply because activities such as "removal of water around the house," "extermination of mosquito larvae," and "cutting grass and cleaning around/inside house" are effective in reducing mosquitoes when the whole village area is targeted at the same time. The organization of cooperative activities is possible when all villagers are involved in "community works." The lifecycle of *Anopheles* mosquitoes suggests that these activities should be conducted once a week.

The analytical model of this study, which is based on the principle of primary health care [34–39] and treats many malaria-related variables at three levels, is judged useful. Without this kind of model framework, it is difficult to clarify complicated causal relationships. The findings of this study, particularly the importance of understanding people's lifestyle and attitudes toward bednet use, are expected to contribute to practical malaria control especially in remote island communities where health services are limited.

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