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# PERMETHRIN-IMPREGNATED BED NETS FOR MALARIA CONTROL IN NORTHERN GUATEMALA: EPIDEMIOLOGIC IMPACT AND COMMUNITY ACCEPTANCE

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*Abstract.* Permethrin-impregnated bed nets were evaluated as a control measure for malaria in northern Guatemala. Twelve hundred forty participants were allocated to one of three experimental groups (impregnated bed nets [IBN], untreated bed nets [UBN], and controls) and followed up for a period of 13 months. The incidence density of malaria was significantly lower in both IBN (86 cases/1,000 person-years) and UBN groups (106/1,000) compared with that in controls (200/1,000). No difference in malaria incidence was noted between the IBN and UBN groups. Complaints of fever and chills were less frequent in the IBN group compared with controls. The participants were enthusiastic about the nets, which they saw as a means for avoiding nuisance insects more than for preventing malaria. Most (85%) wanted to wash their nets every 4–12 weeks, a practice known to shorten the duration of residual insecticide action. Larger studies are needed to determine whether or not impregnated bed nets offer an advantage over untreated nets in this setting.

Thirty-five percent of Guatemala's 8.5 million citizens live in areas where malaria is transmitted.[1–3] The Ministry of Health's National Malaria Service (NMS) divides the country into three operational zones: north, eastcentral, and south. Intradomiciliary insecticide spraying programs directed by the NMS have focused on the southern zone, which is an area intensely organized by the agro-export industry. However, malaria has become a particular problem in the isolated north zone, a forested region extending from the borders with Mexico and Belize southward to Lake Izabal and the Caribbean coast. According to NMS statistics, the annual parasite incidence (API) in the north increased from 21 episodes per 1,000 population in 1977 to 29/1,000 in 1985.[1] More than 32,000 cases were reported in the north in 1988, more than in any other zone. The NMS response to the increase in malaria in the north has been hindered by financial constraints. In addition, expansion of the intradomiciliary spraying program is not a practical option given the difficulty of transportation in that region.

An alternative to spraying is the use of bed nets impregnated with pyrethroid insecticides. Studies in Africa and Asia have shown that impregnated bed nets (IBN) can decrease the incidence of malaria, reduce density of parasitemia, and lower the rates of febrile illness.[4–7] Furthermore, the use of IBN does not require the same degree of vertical delivery requisite for household spraying programs. To determine whether or not IBN were an efficacious control measure for malaria, and acceptable to the local populace, we conducted a longitudinal, controlled study of IBN in several northern villages.

## MATERIALS AND METHODS

### *The study area*

The study was conducted in Los Amates county in the department of Izabal. The economy of this area is based on the production of cattle, bananas, and rice. National Malaria Service statistics for the 70 communities (combined 1988 population of 30,061) in Los Amates showed an increase in malaria from 299 cases in 1979 to 1,328 cases in 1988. Approximately 95% of the reported cases were *Plasmodium vivax;* the remainder were *P. falciparum.* The most recent data on malaria for Los Amates were reviewed at the NMS Northern Regional headquarters in

Puerto Barrios. Five study villages were chosen from among those Los Amates communities that met the following criteria: active NMS voluntary collaborators (VCs), APIs consistently greater than 20/1,000 for several years, year-round accessibility, and no recent NMS spraying operations.

The five communities (A–E) selected for study had a total population of 2,132 (range 104–710). The villages were at elevations of 300–400 meters above sea level and were separated from one another by at least 2 km. The last NMS domiciliary spraying in these villages occurred during March–April 1989, and further spraying was suspended for the duration of the bed net study. During the 12-month period immediately prior to the study (August 1989–July 1990), VCs in the five communities reported 91 cases of malaria (99% *P. vivax),* resulting in a prior year API (PYAPI) of 43/1,000 (range 20–67/1,000).

After describing the study and obtaining consent, we divided the participating households into three study groups: those receiving IBN, those receiving untreated bed nets (UBN), and those without bed nets (controls). All households in community A (Nahua-PYAPI 45) were offered IBN, and all households in community B (Dakota-PYAPI 35) were offered UBN. In both communities C (Palmilla-PYAPI 30) and D (Rio Blanco-PYAPI 67), 50 households were randomly selected; 25 received IBN and the other 25 served as controls. All volunteers from community E (La Democracia-PYAPI 20) served as controls. Once the households were assigned, a census was performed, sleeping habits were verified, and all participants were assigned an individual ID number. The census was updated every four months. During each census, we verified that nets were in use by participants in the IBN and UBN groups, and not in use among the controls.

### *Bed net impregnation and distribution*

The bed nets were manufactured locally in the dimensions 122 (width) × 213 (length) × 183 cm (height) (area = 14.9 $m^2$) at a unit cost of US $6.50. The netting was made of polyester with an aperture diameter of 1.6 mm; three pastel colors were used (blue, beige, and yellow). The IBN groups received nets that had been soaked for 2 min in a solution of a 10% permethrin formulation (Peripel E.C.®; Rousel-Uclaf Laboratories, Paris, France) diluted to deliver 500 mg/$m^2$ of insecticide material. The nets were wrung to remove excess fluid, and then hung on ropes to dry. The cost of permethrin needed to treat a single bed net was approximately US $0.50.

The IBN and UBN were hung in the communities by project staff in September 1990. Households having more than one bed were provided nets of different colors. At the time of net distribution, the proper use and care of nets was discussed with the female head of household. Participants in the IBN and UBN groups agreed to use the nets every night and not to wash them until advised. The nets were not to be taken down, and side panels were to be lowered from the folded positions at dusk. Any net that was damaged during the course of the study was repaired or replaced. At the completion of the study, the nets became the property of the participants, and UBN were given free of charge to the control households.

Following recommendations of the permethrin manufacturer, all IBN were reimpregnated after six months of use. In April 1991, all bed nets were washed by the villagers; the IBN were then collected by project staff, reimpregnated (in the same manner described above), and returned to their original households.

### *Malaria diagnosis and treatment*

Parasitemia was diagnosed using Giemsa-stained thick blood smears. Slides obtained from patients were labeled with the patient's ID number and the date, and transported to our laboratory in Guatemala City. The stained slides were read by a single technician, unaware of experimental group membership. At least 100 high-powered fields per slide were examined for malaria parasites. Blood films having parasites were read quantitatively by counting the number of trophozoites and gametocytes per 200 white blood cells (WBC). Parasite density (parasites/$mm^3$) was calculated assuming 6,000 WBC/$mm^3$.

A case of acute malaria was defined as a (self-reported) febrile illness associated with parasitemia. Cases of asymptomatic parasitemia were identified in the community-wide blood surveys (see below). Both asymptomatic and symptomatic patients were offered primaquine and chloroquine treatment within 10 days of diagnosis. Radical (curative) treatment was administered using the current NMS age-based dosage scheme:

a three-day course of chloroquine (approximately 25 mg/kg base total dose) and primaquine (approximately 0.3 mg/kg base/day) was given for *P. falciparum* infections, while villagers with *P. vivax* infections received an additional two days of treatment with primaquine. If a participant had more than one episode of acute malaria during the study, those additional episodes were considered to be due to a relapse/recrudescence of the previous episode unless 1) the entire course of radical treatment had been administered after the previous episode, and 2) the new illness occurred more than six months after the previous episode.

*Identification of malaria cases*

To determine the point prevalence of malaria, we performed three study-wide blood surveys in which thick blood smears were obtained from at least 80% of the study participants. The three blood surveys were conducted one month before the distribution of the bed nets, and six and 12 months after distribution.

Continuous community surveillance was accomplished by seven resident VCs: one each in communities A, B, and E, and two in the larger communities C and D. These VCs were functioning as NMS agents before the project began; they were well known in the communities as a source of free malaria diagnosis and treatment.[3, 8] Patients who thought they had malaria could visit the VC at any time to have a blood smear taken. The VC then provided presumptive malaria treatment of a single dose of approximately 10 mg/kg base of chloroquine. The VC were visited weekly by project field workers to collect slides, replenish medicines and materials, and leave radical treatment for patients recently diagnosed as having malaria.

In addition to the VC system, symptom surveys were conducted twice a month in all participating households. Persons complaining of fever were asked to give an unstructured account of any additional symptoms; parents answered for young children. No prompting was used to elicit the resulting list of symptoms. A thick blood smear was taken if the patient had not previously visited the VC.

*Community acceptance*

One, six, and 12 months after bed net distribution, interviews were performed in 100 households selected randomly from among the IBN and UBN groups. Two Guatemalan women experienced in rural knowledge, attitudes, and practices survey techniques visited the female head of selected households and recorded opinions about the bed nets. A standardized questionnaire was administered that included both open-ended and closed (true-false) questions. To determine whether or not the bed nets had been used the preceding night, the interviewers made unannounced visits in randomly selected IBN and UBN households during the early morning hours (5:00 AM to 6:30 AM). In addition, on their bimonthly rounds, the symptom survey team checked the positioning and condition of the bed nets.

*Analysis*

Proportions were compared with a chi-square test or Fisher's exact test, and means were compared with the Student's *t*-test or the Kruskal-Wallis test. The incidence study lasted from October 1, 1990 to October 31, 1991 (13 months); malaria incidence during August and September 1990 was considered as a baseline. Villagers included in the final analysis had 1) an occupation that did not require routine overnight travel, 2) participated in a study group for at least 120 days, and 3) participated in at least one blood survey. Incidence densities were calculated for each experimental group by dividing the number of malaria cases by the sum of the participant observation time. The values were expressed as cases per 1,000 person-years of observation and compared using a z-score computed from estimates generated by Survey Data Analysis Software (SUDAAN; Research Triangle Institute, Research Triangle Park, NC). Normal probability tables were used to derive the corresponding *P* values.

## RESULTS

*Epidemiologic evaluation*

Of 1,518 persons initially enrolled in the study, 1,274 (84%) met the criteria for entry into the analysis. Loss of original enrollees resulted primarily from emigration. Six hundred participants slept under IBN, 333 under UBN, and 341 served as controls (Table 1). The characteristics of the participants were similar among the three

TABLE 1
*Characteristics of the study groups**

| | Study group | | | Total |
|---|---|---|---|---|
| | Controls | IBN | UBN | |
| Community | CDE | ACD | B | |
| No. (%) households | 63 (26) | 191 (48) | 65 (26) | 246 (100) |
| No. (%) of participants | 341 (27) | 600 (47) | 333 (26) | 1,274 (100) |
| Mean age (years) | 21.4 | 20.4 | 20.9 | 20.8 |
| % males | 52 | 50 | 50 | 50 |
| No. of bed nets | 0 | 388 | 206 | 594 |
| Persons/bed net | 0 | 1.5 | 1.6 | 1.6† |

* IBN = impregnated bed nets; UBN = untreated bed nets.
† In groups receiving bed nets.

study groups. The mean time of individual observation was 378 days, and 88% of participants completed the entire (15-month) study.

Two hundred ninety-six cases of malaria were diagnosed; 90% of these were *P. vivax* infections and 70% were identified by the VC. Fifty-four of the 296 cases (18%) were judged to be either relapsing vivax malaria (50 cases) or recrudescence of an earlier falciparum infection (four cases). Of the remaining 242 cases, 63 (42 acute cases and 21 asymptomatic parasitemias) from August to September 1990 were considered as baseline. The 42 acute baseline cases were distributed evenly among the participants of the three groups (incidence rates: controls 29/1,000, IBN 38/1,000, UBN 27/1,000). One hundred seventy-nine cases of malaria occurred from October 1, 1990 to October 31, 1991; of these, 19 were asymptomatic parasitemias detected in the second and third blood surveys. Thus, 160 acute cases were noted among the experimental groups formed after net distribution; if the baseline cases are included in the total, 202 acute cases occurred.

Figure 1 shows the monthly incidence of acute malaria during the surveillance period (n = 202). The distribution of bed nets had no apparent impact on incidence during the remainder of the 1990 transmission season, and incidence decreased in all groups during the December to March dry season. When malaria transmission resumed in May 1991, monthly rates in the IBN and the UBN groups did not parallel the increase observed among controls.

One hundred sixty cases of malaria occurred after distribution of the bed nets (Table 2). Compared with controls, the overall incidence density was significantly lower in both groups using bed nets. Impregnated bed nets resulted in a 57% decrease in incidence of malaria, while the untreated bed nets lowered malaria incidence by 47%. No statistical difference in incidence density was evident between the IBN and UBN groups. Age and parasite densities of participants with malaria did not vary according to experimental group, but fewer cases of falciparum malaria were noted in the IBN group. More women than men acquired infection in the control group compared with the UBN group.

Similar participation rates among the study groups were obtained in each of the three blood surveys. Sixty-nine percent of the participants provided thick blood smears in all three community-wide surveys, 23% in two, and 9% in just one. A total of 50 cases of malaria were detected in the blood surveys; 40 (80%) of these were asymptomatic parasitemias. Prevalence decreased in all three groups at the six-month (dry season) measurement (Table 3). In the third survey, 12 months after net distribution, lower prevalence was observed in all three groups compared with baseline. The changes were not statistically significant between groups at a given survey, or within groups with time.

There were 565 episodes of perceived fever recorded during symptom surveys (443 episodes per 1,000 inhabitants). No difference in the rate of reported febrile illnesses was noted among study groups (Table 4). Twenty-three percent of febrile episodes among interviewed participants were associated with parasitemia. Symptoms commonly mentioned as occurring with the fever were headache, body ache, and chills (escalofríos). Compared with a report of fever alone, neither headache with fever nor body ache with fever were better predictors of slide positivity. However, the slide positivity rate was 31% among patients reporting chills with their febrile epi-

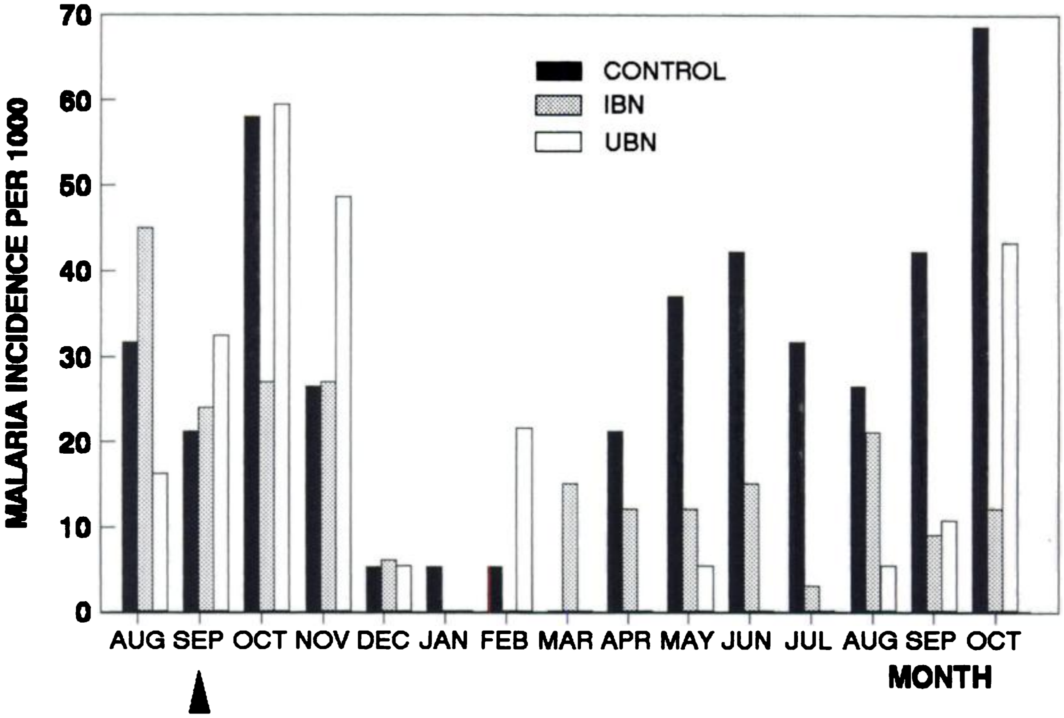


FIGURE 1. Monthly incidence of acute malaria, by study group. IBN = permethrin-impregnated bed net group; UBN = untreated bed net group. The **arrow** indicates distribution of bed nets.

sode; a 35% improvement in the predictive value for malaria versus a report of fever alone. Compared with controls, the rate of chills with fever was significantly lower in the IBN group ($P < 0.05$).

TABLE 2
*Malaria incidence, by study group**

| | Controls (n = 341) | IBN (n = 600) | UBN (n = 333) | Total (n = 1,274) |
|---|---|---|---|---|
| Cases | 70 | 53 | 37 | 160 |
| Mean age, years | 20 | 21 | 25 | 22 |
| % males | 47 | 60 | 70† | 57 |
| % *P. falciparum* | 16‡ | 2 | 30‡ | 14 |
| Mean parasite density (/mm³) | 3,400 | 3,304 | 5,142 | 3,776 |
| Crude incidence§ | 205 | 88 | 111 | 126 |
| Incidence density¶ | 200 | 86† | 106† | 121 |
| % reduction of malaria | | 57 | 47 | |

* IBN = impregnated bed nets; UBN = untreated bed nets.
† $P < 0.05$ versus controls.
‡ $P < 0.05$ versus IBN.
§ Crude incidence is expressed as cases per 1,000 participants.
¶ Incidence density is expressed as cases per 1,000 person-years of observation.

*Community acceptance*

The bed nets were enthusiastically accepted by all but one of the 294 persons interviewed. Major reasons that respondents gave for using bed nets included to decrease insect biting and to have a better night's sleep (Table 5). The role of nets in improving health was mentioned by 11%, and in malaria prevention by only 7%. Only one per-

TABLE 3
*Point prevalence of malaria as determined in three blood surveys, by study group**

| | % positive (no. sampled) | | | |
|---|---|---|---|---|
| | Study group | | | |
| Survey | Controls | IBN | UBN | Total |
| One month prior to net distribution | 2.4 (208) | 2.9 (517) | 2.7 (299) | 2.7 (1,024) |
| Six months after net distribution | 0.7 (297) | 0.2 (560) | 0.6 (310) | 0.4 (1,167) |
| Twelve months after net distribution | 1.7 (293) | 1.3 (529) | 1.7 (299) | 1.5 (1,121) |

* IBN = impregnated bed nets; UBN = untreated bed nets. Point prevalence calculations include both symptomatic (n = 10) and asymptomatic parasitemias (n = 40). No changes were statistically significant. The six-month survey was performed during the dry season.

TABLE 4

*Symptoms (rate per thousand) reported for a 13-month observation period, by study group**

| Symptom | Controls | IBN | UBN |
|---|---|---|---|
| Fever† | 496 | 437 | 402 |
| Headache and fever | 290 | 222 | 231 |
| Myalgias (dolor cuerpo) and fever | 249 | 211 | 204 |
| Chills (escalofrios) and fever | 219 | 141‡ | 192 |

* IBN = impregnated bed nets; UBN = untreated bed nets.
† With or without other symptoms.
‡ $P < 0.05$ versus controls.

TABLE 5

*Reasons to use bed nets given by 296 participants in the UBN and IBN experimental groups**

| Reason | Percent† |
|---|---|
| To avoid mosquito bites | 56 |
| To improve sleep | 21 |
| To avoid la plaga‡ | 14 |
| To improve health | 11 |
| To prevent malaria | 7 |

* UBN = untreated bed nets; IBN = impregnated bed nets.
† Amounts total more than 100% because multiple responses (not just the first) were allowed to answer the question. Because response patterns did not vary between the three surveys, aggregate results are presented.
‡ Literally translated as the plague, this category includes all biting insects (mosquitoes, reduviids, scorpions, spiders, etc.) as well as snakes, bats, and rats.

son mentioned the use of nets for privacy. Ninety-seven percent found the large dimensions and wide polyester mesh resulted in comfortable ventilation even on very hot nights. However, 25% thought the net material and construction were too fragile, and 16% reported having to mend one or more of their nets by the third survey (after 12 months of use). The attractiveness of the nets was listed as being important by 91% of respondents. Fifty-five percent estimated the cost of the nets to be greater than the actual cost. Response patterns did not vary between surveys.

No serious barriers to use of the IBN were encountered. Four percent of respondents reported that the IBN had an unpleasant odor. One person (in the first survey) voiced concern about potential poisoning from sleeping near impregnated netting, but there was no report or evidence of any human or animal toxicity during the study. Similar percentages of respondents in the IBN (32%) and UBN (31%) said that there were fewer mosquitoes inside their houses after hanging the bed nets. To increase the repellent effect of the IBN, we asked the participants to habitually lower the net sidings (from their folded daytime position) at dusk. However, a large percentage (44%) of respondents said they did not comply with that request. They chose instead to lower their nets just before getting into bed. When asked why, the noncompliers said that the nets were at greater risk of being torn by children and household animals in the lowered position; thus, they kept their nets in the more protected folded position as much as possible.

In 94% of the early morning unannounced visits, nets were found to be in use. However, in 5% of the interviews, the respondent reported that at least one household member was not using a bed net. This percentage changed very little during the course of the study (5.1% after the first survey, 6.1% after the second, and 3.1% after the third). Seventy-one percent of those not using bed nets were unmarried men who preferred to sleep in hammocks. Hammock sleepers said they would use bed nets only if they could be adapted to fit their hammocks. The unprotected hammocks were also used during the day and early evening hours as cradles. Since small children sleeping alone might easily roll out of a bed, mothers would place them in hammocks, which were more secure. When the mothers retired, they took their infants with them to the net-protected beds.

Eighty-five percent of respondents said they would prefer to wash their nets at least every three months, and 45% would wash them at least monthly. The color of the bed nets proved to be an important consideration in this context. Of the three colors of nets provided to the participants (blue, beige, and yellow), beige was perceived to soil least easily. For this reason, beige was the preferred color, even though the blue and yellow colors were considered to be equally attractive. Yellow was considered the most unsightly when dirty.

## DISCUSSION

Many malaria-endemic areas in Latin America and the Caribbean have low or episodic transmission that may be further reduced by bed net use.[5] Thus far, however, few studies have documented the effectiveness of IBN for malaria control in the New World.[5,9,10] In northern Guatemala, we found that bed net use reduced malaria incidence. Bed net impregnation, however, did not make a major contribution to this reduction, and we conclude that the principal protective attribute was the physical barrier against the vector. Still, there are reasons to believe that IBN may be a worthy investment for a malaria control program in northern Guatemala, where anopheline resistance to pyrethroids is low. First, IBN users (but not UBN users) had fewer episodes of clinical malaria (fever and chills) than did controls. Second, other investigators have shown that impregnation can maintain the protective barrier even after the bed netting becomes torn.[11] Thus, insecticide treatment extends the time a given net may be effectively used. Finally, entomologic studies were also performed in these villages (Richards FO, unpublished data). Ninety-nine percent of anophelines in human landing captures were *Anopheles albimanus* and *An. vestitipennis.* Release-recapture studies demonstrated increased mosquito exit rates of mosquitoes placed in IBN houses compared with controls and UBN houses. No differences were noted in mortality rates among recaptured mosquitoes. These findings suggested that IBN functioned primarily by repelling vectors from the houses.

Bermejo and Veeken reviewed published epidemiologic assessments of impregnated bed nets and noted several common methodologic flaws, including 1) poorly formulated case definitions of malaria, 2) inappropriate (nonrandom) selection of controls, and 3) insufficient sample sizes to detect differences between groups.[7] These three errors are addressed below as they pertain to our study.

1) Case definition: in this study, acute malaria was defined in such a way to avoid counting relapses or recrudescences as newly acquired infections. As a result of this definition, we excluded from the final analysis 18% of all symptomatic parasitemias identified by the surveillance system. The issue of relapsing malaria has not been previously addressed since most other IBN studies are from regions where *P. falciparum* is the predominant species.

2) Selection of controls: there is considerable debate about optimal selection of controls for IBN studies.[5,7] Community-wide bed net distribution, on the one hand, requires observation of another (control) community having similar transmission characteristics. However, since there are almost always a priori differences in malaria transmission between communities, a perfectly matched control community cannot be identified without an extended period of baseline data collection. On the other hand, having both IBN and control households in the same community is also problematic, since the repellent effects of permethrin may force the vector into neighboring control households. An increase of the risk of malaria among controls would make the IBN appear more protective than they actually are. Finally, most IBN studies are not designed to include UBN controls.

In this study, the IBN and control groups were composed of a combination of the designs discussed above: community A had complete IBN intervention, while those in community E served only as controls, and communities C and D included randomly selected IBN and control households. The UBN group was composed of participants from only one community (community B). Baseline malaria incidence collected for two months prior to net distribution suggested that the study groups were comparable. However, the NMS previous year API figures suggested that the communities themselves were not comparable. The most striking difference during the study was the fact that 90% of falciparum malaria cases occurred in communities B (UBN) and E (control). Thus, the lower rate of falciparum malaria in the IBN group was not due to the intervention, but likely a result of these a priori community differences.

3) Sample sizes: although the study was large enough to detect the considerable difference in malaria risk between bed net users and controls, the numbers were insufficient to distinguish more subtle differences that might have existed between the IBN and UBN groups. At the observed incidence rates, 3,700 persons per group would be needed for sufficient power (beta = 0.80) to test the hypothesis that IBN provided more protection than UBN.

The incidence of malaria in the five study communities was three times greater than we had projected using available NMS passive surveillance data generated by the voluntary collaborator network. This finding was consistent with a report by Ruebush and others, who found that the VC surveillance system registered only about 25% of malaria cases.[3] Villagers who were interviewed in the study of Rubush and others complained that their VC usually had no medicine, and that blood smear examination results did not become available until long after the fever had resolved. Indeed, most of the symptomatic persons purchased their antimalarials from local stores and pharmacies. In contrast, we made certain that symptomatic patients always found the VC well-supplied with free chloroquine, and that results of blood tests and follow-up radical treatment were available within 10 days. As a result, symptomatic persons almost always visited the community VC, accounting for the fact that 70% of acute malaria episodes were identified by passive case detection activities.

A desire for a good night's sleep was the principle motivational force driving the use of bed nets; the health advantages were perceived as a secondary benefit. It was interesting to note that few participants cited privacy as a reason for using nets, despite the closeness of the living conditions. To the contrary, most enjoyed the openness and breezy ventilation provided by the large dimensions and mesh of the bed nets. Villagers considered their bed nets decorative, and efforts were made to preserve their attractiveness by keeping nets clean and well protected. Such concerns might result in two important practices having major implications for the success of an IBN program: frequent washing and irregular use. Each washing would likely diminish the permethrin concentration by 30–40% (Richards FO, unpublished data), so that at the rate of desired washing, IBN effectiveness would be reduced before the end of a transmission season. In an effort to preserve the integrity of their nets, villagers would predictably use them only when the insect nuisance was greatest. Thus, the biting activity of *Culex* species, the more abundant domestic mosquito, would likely dictate bed net use.

Bed net possession in the villages prior to the study was uncommon. Nets were considered to be luxury items because their cost was deemed beyond the family means. However, after having the nets for some months, villagers began to perceive them as essential; that is, bed nets lost their luxury item status. In fact, 71% of interviewees said they would purchase their nets rather than lose them. The willingness to purchase the nets was most obvious when we collected the bed nets for reimpregnation. Despite our attempts to reassure the villagers that the nets would be promptly returned, the villagers actively bartered for their immediate purchase. From this observation, we conclude that if a large control program using bed nets is implemented, the nets should first be distributed (loaned) without charge. Cost recovery schemes should be introduced later, when household economics would be more readily juggled to allow for the purchase of a then essential item.

Community acceptance and participation are fundamental requirements for the success of any program that is to be delivered through the primary health care system. Distribution of bed nets in northern Guatemala undoubtedly would be popular in most communities. In contrast, we doubt there would be a universal or spontaneous acceptance of an IBN program, particularly one designed to use voluntary village labor to treat nets.[4, 5] Based on our experience, a motivational program would first need to explain the purpose of insecticide treatment and address concerns about toxicity. Such a program should be carefully designed and piloted to evaluate the effectiveness of the message.

In conclusion, we found bed net use (regardless of impregnation status) reduced malaria incidence. Additional benefit from the treatment of bed nets with permethrin may have occurred, but could not be demonstrated given the limited power of the study. Further epidemiologic and sociological studies are needed to determine the role of IBN for malaria control in northern Guatemala.

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