

Trials of Improved Practices (TIPs): A Strategy for Making Long-Lasting Nets Last Longer?

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Abstract. Long-lasting insecticidal net (LLIN) use is a proven malaria prevention method. Mass distribution has greatly expanded LLIN access in sub-Saharan Africa, but a gap remains between LLIN ownership and use. Furthermore, LLINs wear out more quickly than anticipated. This paper suggests a participatory research strategy—trials of improved practices (TIPs)—that could identify locally appropriate approaches to prolonging net life and increasing effective use. We used TIPs to overcome barriers to optimal net use in the Peruvian Amazon. Working with 15 families in three villages, we tested home treatment of cotton nets, use of an alternative netting fabric, and alternative washing and care instructions. TIPs helped confirm feasibility of these interventions. Although our findings are time- and context-specific, TIPs could help improve consistency and effectiveness of current LLIN use and prolong net lifespan in sub-Saharan Africa and elsewhere. This would help maximize the value of shrinking donor resources for malaria.

INTRODUCTION

Insecticide-treated bed nets (ITNs) are effective at preventing malaria and can reduce malaria mortality in children by 16–38%.^{1–7} In recent years, ITN ownership in Africa has grown steadily thanks to promotion, subsidies, and mass distribution. The World Health Organization (WHO) now estimates that 50% of sub-Saharan African households own at least one ITN, up from 3% in 2000. Some countries have achieved near universal coverage, primarily through free mass distribution. Nearly 300 million ITNs were distributed in sub-Saharan Africa between 2008 and 2011.⁸

However, studies show that between 15% and 50% of available nets go unused.^{9,10} Principle reasons include discomfort, particularly because of heat; perceived low mosquito density; being away from home or having a visitor or other household member use the net; distribution of nets that are the wrong shape or size for the household or sleeping area; and sleeping outdoors because of the heat.¹¹ Concerns with net color (such as white nets being associated with funeral shrouds) and practical challenges of net installation have also been reported as reasons for non-use.¹² Still, our understanding of reasons for non-use and suboptimal use remains limited.^{11,13}

In addition to optimizing net use, it is also vital to maximize net lifespan. Manufacturers claim that today's long-lasting insecticidal nets (LLINs) remain effective for 20 or more washes and up to 5 years.^{14–17} However, field experience shows that LLIN fabric may wear out in as little as 14 months.^{18–20} In addition, frequent or vigorous net washing and inadequate net handling can greatly reduce the effective life of the insecticide.^{21,22} Better net care and maintenance could prolong net life, thus stretching scarce financial resources and minimizing coverage gaps caused by worn nets.²¹ The need for more rapid replacement of existing nets, coupled with funding cutbacks because of the global financial crisis, makes prolonging net life even more urgent.^{23,24}

TRIALS OF IMPROVED PRACTICES: FOCUSING ON PRACTICAL SOLUTIONS

Maximizing net life requires identifying use, storage, and washing practices that are locally acceptable and feasible. Trials of improved practices (TIPs) are a participatory formative research approach used to test and refine potential health interventions on a small scale before introducing them broadly.²⁵ Health researchers enter into a dialogue with members of the target population: a small number of individuals or households agree to serve as community consultants, try out several practices over a period of time, and then discuss the pros and cons of each practice with researchers. Working together, researchers and participants identify interventions that both address the health problem and are feasible and culturally acceptable. Unlike focus groups or interviews, where informants might discuss a proposed intervention in the abstract, TIPs enlist members of the target population to pilot test the intervention in their own homes, determine from experience what is or is not feasible, and recommend necessary modifications. By drawing on participant experience, the researchers designing an intervention can pinpoint potential obstacles to implementation, develop strategies for overcoming those obstacles, and discard components of an intervention for which the obstacles seem insurmountable. TIPs can also provide the basis for negotiating the feasible when the ideal—at least from a public health perspective—proves unattainable.

TIPs were developed in the early 1980s in the field of child nutrition.²⁶ The approach has informed campaigns to promote exclusive breastfeeding and healthy weaning foods in Latin America, Asia, and Africa.^{27–31} TIPs have also shaped interventions related to newborn care, indoor air quality, dengue prevention, human immunodeficiency virus (HIV), basic hygiene, and family planning.^{26,32–38} This paper reports on trials of improved practices designed to maximize effective ITN use in a malaria-endemic region of the Peruvian Amazon. The study took place in 2000–2001, before the development of LLINs. Key objectives were to test whether net users would:

- (1) find home-based net treatment or retreatment with insecticide feasible;
- (2) find a denser netting fabric more acceptable than the light fabric used in existing ITNs (previous research had shown that users found the existing fabric too thin and transparent and preferred their untreated cotton nets)³⁹;

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- (3) be willing to increase the intervals between washings with a colored rather than a white net, thus prolonging insecticide effectiveness; and
- (4) be willing to store nets during the day to protect them from sunlight, dust, smoke, and wear, thus increasing insecticide and fabric lifespan.

LLINs have made home-based treatment less relevant. However, identifying participatory strategies to prolong net life and optimize use remains quite pertinent. The TIPs approach described here may serve as a model for addressing critical net questions today.

METHODS

Study site. This study took place in three rural villages within 2 hours of the city of Iquitos. All had a mestizo (Spanish–Amerindian) population, an economy based on subsistence and small-market agriculture, and houses of rough-hewn boards or logs with palm-thatch roofs. At the time of the study, all were surrounded by secondary growth tropical rainforest. None had electricity, plumbing, or potable water. Populations in a 2002 census were 311, 255, and 154, respectively.

Previous net use. Untreated bed nets have been used widely in the region for many years, but ITNs were virtually unknown until the late 1990s. Instead, most households owned nets made of a densely woven opaque cotton fabric known locally as *tocuyo*. After an epidemic malaria outbreak in 1997, the Peruvian Ministry of Health (MOH) sprayed existing *tocuyo* nets with deltamethrin and then launched an ITN distribution campaign. The MOH distributed ITNs made of white 156-mesh multifilament polyester treated with 25 mg/m² deltamethrin. When the study began, most households in one village had received an MOH-distributed ITN. Residents of a second village had received similar nets from a non-governmental organization (NGO). The third village had received no ITNs.

Dissatisfaction with MOH nets. A 2000 evaluation found that many recipients disliked the white 156-mesh ITNs, because they were too transparent and provided no protection against biting sand fleas (*manta blanca*), which were small enough to pass through the mesh.³⁹ Another complaint was that the lightweight fabric and open mesh left occupants feeling cold at night compared with *tocuyo*. In addition, users reported that the white fabric soiled rapidly, required frequent washing, and wore out more quickly than their traditional *tocuyo* nets.^{40,41} Participants in the earlier research had expressed a strong preference for *tocuyo* over polyester. These findings served as the basis for the trials of improved practices described here.

TIPs phase 1: Home-based impregnation of existing nets. In phase 1, we tested home-based insecticide impregnation of traditional *tocuyo* nets. In addition to determining the feasibility of home treatment, we also wanted to know how long owners of treated *tocuyo* nets would be willing to use them between washings, their perceptions about how long the insecticide continued to be effective, and, because deltamethrin is photosensitive, whether users would protect their nets from sunlight during the day.

Based on a process agreed to by village residents, an elected official from each village selected five households by

lottery from among those households interested in participating. The lottery took place at a public meeting. Through a baseline survey of the 15 households, we documented basic household demographics plus the number and type of beds and nets, the average time between net washings, and other relevant information. We supplied each household with residual insecticide tablets (KO-tab: 25 mg/kg deltamethrin, Agr Evo [Aventis], Lima, Peru.), gloves, a black plastic bag for treatment and storage, and assistance from project staff to treat the household's nets. After treatment, participants were asked to refrain from washing their nets for 3 months and store them out of sunlight during the day. A field worker revisited each household 1–3 days after treatment and then approximately one time per week for the next 3 months. At each visit, the field worker administered a 37-item questionnaire about whether and how household members had used each treated net, at what time it was hung and taken down, whether it had been washed, what family members thought of the net, and whether anyone had experienced an adverse reaction. During her visit, the field worker also recorded observations on each net's location and condition.

An exit interview took place at 3 months or when a family had washed all its nets, whichever came first. This interview examined whether participants would want to treat their nets again and if so, how much they would be willing to pay for the insecticide. The field worker also asked how long the insecticide seemed effective, whether and when the interviewee began to notice a diminishing effect, and how often they would recommend retreating a net. Finally, participants were asked whether they would recommend net treatment to their neighbors and if they could suggest any improvements.

TIPs phase 2: Testing pre-treated polyester nets. In phase 2, which immediately followed phase 1, we asked the same 15 households to test a more tightly woven lime green polyester jersey cloth net (Siamdutch Mosquito Netting Company, Ltd., Bangkok, Thailand) chosen to address the deficiencies reported with the existing ITNs.³⁹ We asked participants to use their existing *tocuyo* and polyester nets and the jersey cloth nets simultaneously and compare what they liked and disliked about each net. After distribution, the field worker visited each family within 1–3 days, interviewed family members about their initial reactions, and continued with weekly surveillance visits for 3 months using a structured questionnaire similar to the questionnaire used during phase 1.

Ethics review. This study was approved by the Institutional Review Board of the Johns Hopkins Bloomberg School of Public Health (CHR#: H.22.00.09.06.A), the Ethics Committee of the Asociación Benéfica PRISMA (CE211.00), and the Loreto Regional Directorate of Health.

RESULTS

Phase 1: Home-based net treatment of *tocuyo* nets. At baseline, the 15 project households owned 45 nets (28 *tocuyo* and 17 polyester). Participants treated 38 nets total: 21 *tocuyo* and 17 polyester. All participants said that treating their nets was easy and that the insecticide was effective for several weeks, although the perceived effect lessened over time. Participants reported sleeping better thanks to decreased insect activity. Although all nets were treated in the morning to allow ample drying time, some participants reported that their *tocuyo* nets remained wet or damp on the first night.

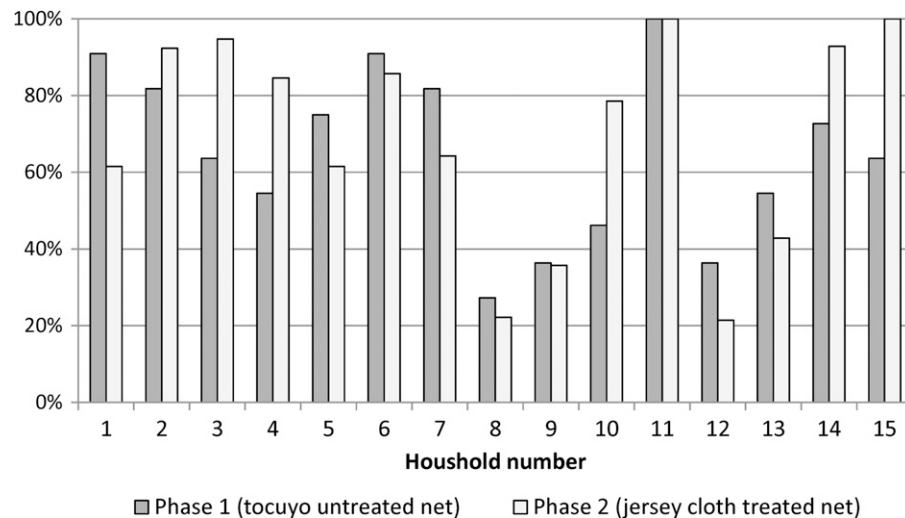


FIGURE 1. Percentage of weekly visits at which all nets were stored in a way that would protect them from sunlight, dust, smoke, and wear when the observer arrived.

Nevertheless, it seems that all participants complied with the request to dry their nets in shade. The usual practice in the study area is to dry nets in bright sunlight so that they can be used again on the same day that they are washed. In phase 1 exit interviews, all participants said that they would like to be able to retreat their nets at home whenever needed and that they would be willing to pay the equivalent of US \$0.50–0.75 per treatment.

Phase 2: Acceptability of pre-treated jersey cloth polyester nets.* Participants mentioned several positive characteristics of jersey cloth compared with tocuyo and 156-mesh polyester. The smaller mesh kept out biting sand fleas. This had been a major complaint with 156-mesh ITNs. Some users also reported that the denser weave kept them warm:

“The weave is nice and tight, you can sleep peacefully: not even the smallest bugs get in. I don’t get cold; it’s just as warm as the tocuyo, maybe because the room is pretty well closed up. It protects me and I don’t feel cold like I did with the other nylon net” (man, age: 68 years).

Many said the color (lime green) was bright and attractive and seemed to show dirt less quickly than white ITNs. Participants saw this feature as an advantage because the colored net required less frequent washing. Several participants reported that the new net was easier to wash: dirt came out quickly with minimal effort, and the net dried rapidly and could be used the same day. This result compared favorably with tocuyo nets, which become heavy and difficult to handle when wet, require scrubbing, and may take 2–3 days to dry. Some added that the fabric did not require bleach or deter-

gent like tocuyo but that it could be washed with regular soap, a cost savings for the household.

Users made relatively few negative comments about the new nets. Participants in five households said that they sometimes felt cold at night, especially when it was raining. In four households, some family members still found it too transparent. As one participant explained, “it’s pretty thin ... for a married couple it should be darker so people aren’t watching us.” Members of two households reported mild skin or eye irritation from the insecticide.

Asked after 14 weeks of surveillance if they preferred their old nets or the new nets, 9 of 15 households chose the new nets, whereas 5 households expressed no strong preference. No one reported preferring their old nets. One household moved out of the area on week 9. All 14 remaining families said that they would recommend a net like the new one to neighbors.

Net storage. Based on observation, most study participants were able to protect their nets from sunlight, dust, smoke, and rain at least some of the time. However, as shown in Figure 1, households varied considerably in the consistency with which they stored their nets, from only 25% of the time (household #8) to 100% (household #11). Table 1 shows reported reasons for not storing nets as suggested. Some participants developed alternative approaches to storage, such as leaving their nets partially hung but bundling and covering them with a sheet or blanket. Others took the nets down and wrapped them in a sheet or a blanket rather than the black plastic bag. These approaches accomplished the same objective as storing a net in the plastic bag but may have been easier or more convenient for participants.

Time to net washing. In baseline interviews, most families reported washing their nets about every 15 days. The most commonly mentioned reason for frequent washing was to maintain good hygiene, because nets get stained from dirt and smoke and begin to smell. We tracked length of time to first washing during both phases (Figure 2). All households refrained from washing their nets for the first 3 weeks of both phases. The first household washed its tocuyo nets on week 4; all polyester nets remained unwashed until week 6. Between

*(Between phases 1 and 2, a daughter in one project family married and set up her own household. Because she had participated in the study’s first phase and took some of the parent household’s nets to her new home, we included her as a participant at the beginning of phase 2. Thus, phase 2 began with 16 households. The daughter was lost to follow-up after week 8.)

TABLE 1
Reasons for not storing nets by household and in total

Reason	No. of households that mentioned this reason	Total mentions (includes mentions on multiple visits to the same household)
Left home early—no time	9	34
Sick person sleeping in net during the day	7	9
Non-sick person using net to rest during the day (child, spouse, or mother with newborn)	6	18
Forgot	6	9
Felt lazy	4	13
Weather was cold—needed net to keep warm	4	4
Someone took net on trip	3	3
Too many other things to do—no time	3	2
Leave it hanging to kill mosquitoes during the day	2	3
Insecticide no longer effective—no reason to store it	2	2
Keeping it in the plastic bag gives it a bad smell	1	4
Room is dark—no need to store the net	1	4
Prefer to leave it hanging	1	3
Needed to wash net	1	2
Other (each mentioned one time)	3	3

weeks 6 and 9, fewer households washed their polyester than their tocuyo nets. By week 11, when tocuyo surveillance ended, 10 of 15 participating households had refrained from washing their tocuyo nets.

In exit interviews, most participants reported that their nets were too dirty and smelly to use longer than 2 months without washing. Most also reported that the insecticide was only minimally effective after 2 months. Some families

who had refrained from washing their nets during the surveillance said they did so only because they were participating in the study.

DISCUSSION

The trials of improved practices discussed here yielded several potentially important findings about ITN use and care. Through TIPS, we learned that owners of tocuyo nets were willing and able to treat their nets at home, that they reported enthusiasm for the idea of purchasing insecticide to retreat their nets when necessary, and that a green ITN with a more tightly woven mesh was more acceptable than the white 156-mesh ITNs that the MOH or NGOs had distributed. Although in previous research, net users had expressed a preference for a colored net with a tighter weave, TIPS provided an opportunity to confirm that preference before investing in a large procurement of new nets. Through TIPS, we also learned that net owners could extend intervals between washing from 2 weeks to 2 months but that promoting 6-month intervals was unrealistic. We learned that net users would protect their nets from environmental hazards (sunlight, smoke, etc.) at least some of the time but that the approach originally suggested by the study might not be the most adequate. Net users might develop more convenient approaches to achieving the same objective. As shown in Table 2, these solutions were all imperfect: ideal from the perspective of neither public health nor the target population, but a compromise that enabled each to respond more effectively to the needs of the other. In other words, TIPS drew on the community's expert knowledge of its own setting to increase an intervention's effectiveness.

TIPS could be similarly useful as a mechanism for addressing current concerns about maximizing LLIN use and lifespan. For instance, in areas where discomfort and heat are key barriers, TIPS might be used to test different strategies for improving indoor airflow or making net use more convenient

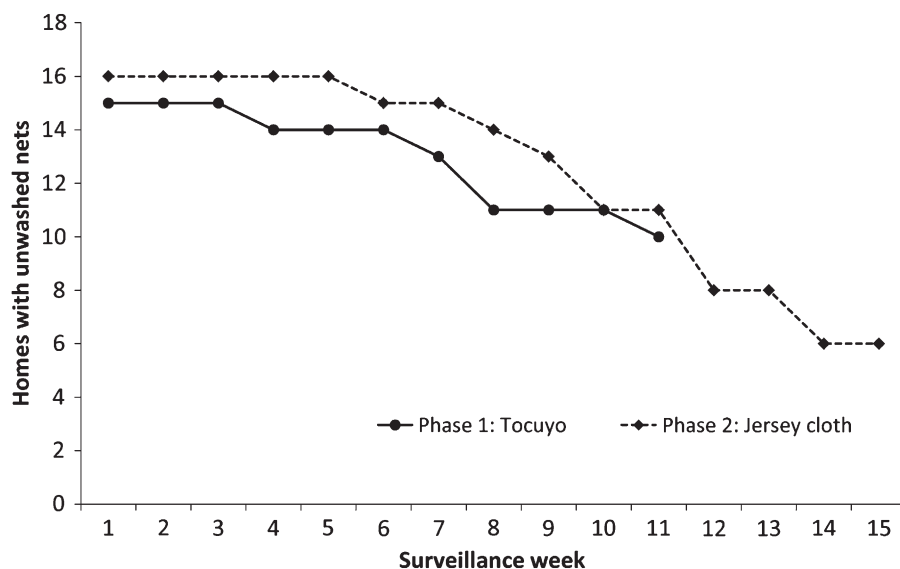


FIGURE 2. Weeks to first washing of bed net (tocuyo and jersey cloth). As explained in the text, the first phase of trials of improved practices began with 15 households. Between phases 1 (using tocuyo) and 2 (jersey cloth), one household divided into two when a daughter married and set up her own household. That new household remained in the study until week 8, when it was lost to follow-up. The family from another study household moved out of the study area after week 9. Thus, phase 2 began with 16 households and ended with 14 households.

TABLE 2

Non-feasible ideal practices from public health and population perspective versus feasible compromise practices developed through small-scale household trials (TIPs)

Ideal practice (public health perspective)	Ideal practice (target population perspective)	Compromise practice through TIPs	Comments
Use standard ITN	Use untreated tocuyo net	Treat tocuyo net with insecticide	The compromise practice is not ideal from the public health perspective, because the insecticide is effective for less time than when impregnated into synthetic netting material. However, it is more effective than an untreated net, especially if insecticide is readily available and affordable to net owners.
		Use a netting fabric with a tighter weave (e.g., jersey cloth)	The compromise practice is not ideal from the net user's perspective, because jersey cloth nets provide less privacy than tocuyo. It is not ideal from the public health perspective, because the fabric is more expensive than 156-mesh polyester. However, it was warmer and offered better protection from smaller biting insects than 156-mesh polyester. It was also effective as a vector control measure for a greater length of time than tocuyo.
Use white ITN	Have a choice of colors	Have a single color attractive to most of the target population	White ITNs are cheaper than colored nets but show dirt more quickly; thus, they are likely to be washed more often and more aggressively. A colored net may last longer than a white net, because it is washed less frequently. It may also be used more frequently, because its attractiveness to the user helps compensate for its limited ability to protect privacy.
Wash net one to two times per year maximum	Wash net every 2 weeks	Wash net every 2 months	Trade off allows net user to maintain adequate hygiene while also prolonging insecticide viability.
Take net down daily and store in a dark place	Leave net hanging	Cover net with sheet or protect it in some more convenient way	

when sleeping outside. In one recent assessment, Ghanaian LLIN recipients suggested just such an approach during home visits and focus group discussions (Harvey SA, unpublished data). TIPs could also help determine optimal ways to hang nets in tight spaces and move them out of the way during the day. One hypothesis worth testing is whether the work of hanging the net every evening and taking it down every morning contributes to inconsistent use. Net users might be more likely to sleep under a net every night if nets were designed so that they could be moved out of the way and protected from environmental damage while still hanging.

Based on tests in Kenya, Atieli and others found that different washing and drying regimens had a significant impact on insecticide bioavailability and knockdown effect in four different LLIN brands.^{21,22} They recommended that net distribution campaigns educate users about more gentle washing approaches. An earlier 5-year longitudinal study by Kilian and others¹⁸ in Uganda found that daily use had even greater impact on insecticide loss than washing but could not identify exactly what factors contributed to this loss. After a 5-year net durability study in Tanzania, Kweka and others²⁰ likewise recommend including education about net maintenance and care as part of all LLIN distributions.

Promoting more careful net care and gentler washing might significantly prolong the effective life of both insecticide and netting fabric. However, the success of any such promotion would hinge on at least two factors. First, we would need to know more about what specific aspects of daily use and handling—in addition to washing—contribute most to net wear and tear. The four studies discussed above^{18,20–22} all describe methods for collecting that type of

information. Second, we would need to determine what net users are prepared to do to prevent or repair net damage. TIPs are an apt approach to addressing this second factor. They could greatly increase a care and repair campaign's likelihood of success by ensuring that the behaviors promoted by such a campaign incorporate local input and are previously vetted and found feasible by the target population. Moreover, because TIPs require a relatively small sample size (15–20 households in a given setting) and take place over a relatively short period of time (3–4 months), they are a cost-effective approach to such testing. For programs aiming to scale up across large, diverse countries, TIPs could be implemented in a range of settings to explore different climatic, cultural, and socioeconomic contexts.

Limitations. The principle limitation to the Peru TIPs results is that there was never an opportunity to test them at scale. After 2001, malaria transmission declined in the region, leading to reallocation of health budgets. As a result, the MOH did not continue ITN distribution. The MOH had permitted experimental use of KO-tab deltamethrin for purposes of this study, but the product was never licensed for retail sale in the country. Although additional smaller outbreaks have occurred in the intervening years, none have reached the epidemic level experienced in 1997–1998. In subsequent years, the malaria control program has focused on opportune diagnosis and treatment rather than vector control as its key strategy. Some might see the small sample size of this study as a limitation, but TIPs are meant to test the feasibility and acceptability of potential interventions with a small number of participants; they are not designed to draw population-level inferences. Weekly visits to each household over a

6-month period might have provoked some research fatigue, leading participants over time to offer rote responses rather than thoughtful answers to routine questions. However, the surveillance involved direct observation as well as interview, and the observer made unannounced visits on different days and at different times; therefore, participants would not have been able to prepare in advance for her visits. Combining observations with interviews served as a two-way validity check: although the core principle of TIPs is that participants evaluate a proposed intervention by testing it out for themselves, observations corroborate what participants report. Conversely, the participant's direct experience with the intervention helps control for possible observer subjectivity. This use of triangulation to guard against bias is common in many in qualitative studies.⁴² Finally, we categorized observation data on net storage into three categories: all nets stored appropriately, some nets stored appropriately, and none stored appropriately. This categorization left us with less than an ideal level of information about net storage practices. In retrospect, recording the status of each net on each visit and describing different net storage practices in more detail would have provided more precise information about net care strategies.

Conclusion. Despite some limitations, TIPs offer a useful approach to identifying and testing practices that may help optimize the use and maximize the lifespan of LLINs.

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