Prevention of Malaria in Long-term Travelers

Lin H. Chen, MD
Mary E. Wilson, MD
Patricia Schlagenhauf, PhD

TRAVELER ARRIVALS WORLDWIDE exceeded 800 million in 2005.1 Today’s mobile populations and global economies lead to extended stays for many travelers. For long-term travelers visiting malaria-endemic countries, recommendations for prevention have been difficult to standardize due to the diversity of long-term travelers and their itineraries, the variation in quality of and access to medical care, the limited data on malaria incidence in travelers overseas, and the lack of controlled studies on long-term safety and efficacy of antimalarial agents. Further complicating the recommendations are the evolution in the intensity of transmission and resistance patterns of the malaria parasites, the seasonality of transmission, and the wide range of international guidelines and travelers’ beliefs and expectations.

EVIDENCE ACQUISITION
We searched the literature using MEDLINE via both OVID and PubMed for relevant studies and articles with a cutoff date of July 2006, using the search terms long-term travel and malaria prevention, long-term malaria chemoprophylaxis, and insect repellent and malaria. We obtained additional references from searching the bibliographies of the selected articles, from dissertations, and from the proceedings of relevant conferences on travel medicine. There were no language restrictions.

Evidence Synthesis Long-term travelers have a higher risk of malaria than short-term travelers. Long-term travelers underuse personal protective measures and adhere poorly to continuous chemoprophylaxis regimens. A number of strategies are used during long-term stays: discontinuation of chemoprophylaxis after the initial period, sequential regimens with different medications for chemoprophylaxis, stand-by emergency self-treatment, and seasonal chemoprophylaxis targeting high-incidence periods or locations. All strategies have advantages and drawbacks. Counterfeit drugs sold in countries endemic for malaria pose serious concern for long-term travelers who purchase their medications overseas. Vivax malaria causes significant illness in travelers, but relapses of vivax malaria are not prevented with the current first-line chemoprophylaxis regimens. Consensus guidelines are needed for prevention of malaria in long-term travelers.

Conclusions Prevention of malaria in long-term travelers is a complex issue and requires expert advice from travel medicine specialists. Recommendations for prevention of malaria in long-term travelers must be individualized.

Context Long-term travelers, defined here as those traveling for periods of 6 months or longer, face particular challenges regarding malaria prevention. Current guidelines for malaria prevention primarily address prevention of Plasmodium falciparum infections in short-term travelers.

Objectives To examine the risk of malaria in long-term travelers, recent developments in personal protective measures, and the safety and tolerability of malaria chemoprophylaxis during long-term use and to consider prevention strategies including continuous chemoprophylaxis, stand-by emergency self-treatment, seasonal prophylaxis, and strategies to prevent primary infection and relapses from P vivax malaria.

©2006 American Medical Association. All rights reserved.
east Asian Journal of Tropical Medicine and Public Health, Transactions of the Royal Society of Tropical Medicine, and Tropical Medicine and International Health. We placed emphasis on the more recent reports, especially systematic reviews, randomized controlled trials, and analyses of travelers' databases. All 3 authors performed the searches and added supplemental references; there were no disagreements.

EVIDENCE SYNTHESIS

Who Are Long-term Travelers?

In the GeoSentinel database (http://istm.org/geosentinel/main.html), 16% of patients with malaria had traveled for longer than 6 months. For the purpose of our discussion, we defined nonimmune travelers as persons who reside in areas without malaria and who therefore do not have immunity to malaria parasites (although even residence in an endemic area does not result in fully protective immunity) and defined long-term travelers as nonimmune travelers visiting endemic areas for longer than 6 months. This is consistent with UK guidelines on the prevention of malaria in long-term travelers. However, many travelers visiting a destination for periods of less than 6 months will confront similar issues. Examples of long-term travelers include diplomats, students, missionaries, Peace Corps Volunteers, military personnel, teachers, field researchers, corporate employees, backpackers, and travelers who have frequent transient stays in malaria-endemic countries, such as airline crews.

Risk of Malaria in Long-term Travelers

An estimated 30,000 cases of malaria, 10,000 of them reported, are imported annually to nonendemic industrialized countries. The risk of malaria varies widely by geographic region. Between 1985 and 1988, the incidence of malaria in European travelers using no chemoprophylaxis was 15.2/1000 travelers per month in East Africa, and 24.2/1000 travelers per month in West Africa. Investigators using Plasmodium falciparum circumsporozoite antibody titers as a measure of malaria exposure found large variation in the proportion of seropositive travelers depending on the area visited: West Africa (22.2%), East Africa (21.8%), and southern Africa (15.4%), in contrast to Central America (4.2%), Southeast Asia (3.4%), East Asia (3.3%), South America (2.4%), and the Indian subcontinent (2.2%). Recent analyses of traveler databases have found the highest risk of acquiring malaria in Africa and Oceania, an intermediate risk in South Asia, and a lower risk in Central America, Southeast Asia, and South America. Long-term travelers, particularly occupational travelers such as miners, are at an even higher risk. In Zambia, 82% of expatriates working for a multinational mining company allegedly had malaria.

Table 1. Summary of Malaria Risk for Various Groups of Long-term Travelers

<table>
<thead>
<tr>
<th>Source</th>
<th>Type of Traveler</th>
<th>Malaria Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blanke,10 2003</td>
<td>Expatriates in Monorogo, Tanzania, language school</td>
<td>4-Fold higher in nonimmune expatriates who used no chemoprophylaxis relative to those who used chemoprophylaxis</td>
</tr>
<tr>
<td>Leutcher and Bagley,11 2003</td>
<td>Peace Corps Volunteers in Madagascar</td>
<td>15.9% of Peace Corps Volunteers reported malaria, or 8 per 100 Peace Corps Volunteers per year</td>
</tr>
<tr>
<td>Ross and Hodge,9 2000</td>
<td>Expatriates working for mining company sites in Africa</td>
<td>82% of expatriate workers in Zambia had diagnosis of malaria</td>
</tr>
<tr>
<td>Adera et al,12 1995</td>
<td>US embassy personnel in Kampa, Uganda</td>
<td>Relative risk was 7.9 for those staying &gt;2 y compared with &lt;1 y; 10-fold increase in those using no chemoprophylaxis vs those taking mefloquine, doxycycline, or chloroquine-primaquin</td>
</tr>
<tr>
<td>Peppiatt and Byass,13 1991</td>
<td>Missionaries on leave to the United Kingdom</td>
<td>87.3 per 1000 persons per year; malaria was the most common illness, and risk was highest in West Africa</td>
</tr>
<tr>
<td>Philippe-Howard et al,14 1990</td>
<td>Returning British travelers</td>
<td>Relative risk in West Africa was 80.3 for a stay of 6-12 mo vs a 1-wk stay</td>
</tr>
<tr>
<td>Lange et al,15 1987</td>
<td>American mission boards</td>
<td>Malaria was the most common nontrivial medical problem; sub-Saharan Africa was region with highest risk</td>
</tr>
<tr>
<td>Mclarty et al,16 1984</td>
<td>Urban expatriates in Dar es Salaam, Tanzania</td>
<td>37.1% reported history of infection with malaria</td>
</tr>
</tbody>
</table>

*Data may be inaccurate because of lack of good laboratory facilities in many areas, often leading to overdiagnosis of malaria.

©2006 American Medical Association. All rights reserved.
flection, protein manifestations of malaria, potential for rapid progression, need for rapid assessment, and possible onset many months after exposure, especially with vivax malaria.

**Personal Protective Measures**

The importance and effectiveness of personal protective measures should be emphasized with long-term travelers, including behaviors to minimize exposure to mosquitoes (eg, stay indoors from dusk to dawn, choose screened accommodations), barrier clothing, insecticide-impregnated bed nets, spraying of residence with insecticide, and application of effective insect repellent. Long-term travelers need concise instructions on clothing and bedding impregnation.21 “Knockdown” sprays (ie, those that kill mosquitoes on contact) can also be recommended, and the concept of “mosquito proofing” living accommodations (eg, maintaining drains, eliminating mosquito breeding sites, and installing screens) should be discussed in detail.22

Insecticides (eg, deltamethrin and permethrin) are designed to kill mosquitoes and can be used effectively as knockdown sprays or in the impregnation of clothes and bed nets. Colombian soldiers who used permethrin-impregnated clothing had a reduced incidence of malaria (3%) compared with controls (14%).23 Insecticide-treated bed nets are also highly effective in malaria prevention.24

Repellents are substances applied to the skin to reduce the attractiveness of humans to mosquitoes and other arthropods. The US Environmental Protection Agency has registered a number of active ingredients as insect repellents: DEET (N,N-diethyl-m-toluamide [or N,N-diethyl-3-methylbenzamide]), picaridin (1-methyl-propyl 2-[2-hydroxyethyl]-1-piperidinecarboxylate [also known as KBR 3023 or Bayrepel]), PMD (p-menthane 3,8-diole [or oil of lemon eucalyptus]), MGK-326 (dipropyl isocinchomeranone), MGK-264 (N-octyl bicycloheptane dicarboximide), IR3535 (ethyl butylacetylaminopropionate), and oil of citronella.25 DEET has the best evidence and longest history of use, and is considered the most reli-

---

**Table 2. Main Results of Recent Comparative Studies on Insect Repellents**

<table>
<thead>
<tr>
<th>Source</th>
<th>Repellents Compared*</th>
<th>Type of Study</th>
<th>Location</th>
<th>Anopheles Species Tested</th>
<th>Efficacy and Duration of Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fradin and Day,29 2002</td>
<td>DEET (23.6%) vs other repellents</td>
<td>Arm-in-cage study</td>
<td>Indoors</td>
<td>None (study tested against Aedes aegypti)</td>
<td>DEET protected for 5 h; efficacy was best of those tested</td>
</tr>
<tr>
<td>Frances et al,30 2002</td>
<td>Picaridin (0.3%)† and 19.2% vs DEET (20%, 33%, and 35%)</td>
<td>Field trial</td>
<td>Northern Queensland, Australia</td>
<td>A farauti ss Laveran</td>
<td>Picaridin (19.2%) is comparable to DEET (35%); nighttime use provided 95% protection for &gt;7-9 h; picaridin (0.3%)† provided &gt;95% protection for only 2 h</td>
</tr>
<tr>
<td>Badolo et al,31 2004</td>
<td>Picaridin (diluted in ethanol) vs DEET</td>
<td>Arm-in-cage study</td>
<td>Laboratory in Burkina Faso</td>
<td>A gambiae sl</td>
<td>Picaridin similar to DEET for A gambiae complex</td>
</tr>
<tr>
<td>Frances et al,32 2004</td>
<td>Picaridin (19.2%) vs DEET (20% and 35%)</td>
<td>Field trial</td>
<td>Northern Territory, Australia</td>
<td>A merakensis Venhuis, A bancrofti Gles</td>
<td>Picaridin provided &gt;95% protection against Anopheles mosquitoes for only 1 h, similar to DEET (35%); DEET (20% in ethanol) protected poorly against Anopheles mosquitoes</td>
</tr>
<tr>
<td>Costantini et al,33 2004</td>
<td>Picaridin vs IR3535 and DEET</td>
<td>Field trial</td>
<td>Burkina Faso</td>
<td>A gambiae sl</td>
<td>Picaridin provided best protection for A gambiae complex after exposure of 10 h; picaridin lasted longer, has longer half life after application on skin than other 2 agents</td>
</tr>
<tr>
<td>Trigg,34 1996</td>
<td>PMD vs DEET</td>
<td>Human-landing catches</td>
<td>Tanzania</td>
<td>A gambiae and A funestus</td>
<td>PMD and DEET protected for 6-7.75 h</td>
</tr>
<tr>
<td>Govere et al,35 2000</td>
<td>PMD (0.574 g) vs DEET (15%) vs Bio-Skincare (BSC)‡</td>
<td>Arm-in-cage study</td>
<td>Indoors</td>
<td>A arabiensis Patton</td>
<td>PMD and DEET provided 90%-100% protection for up to 5-6 h; BSC protected for up to 3-4 h</td>
</tr>
<tr>
<td>Moore et al,36 2002</td>
<td>PMD (30%) vs DEET (15%)</td>
<td>Human-landing catches</td>
<td>Bolivia</td>
<td>A darlingi</td>
<td>PMD provided 97% protection for 4 h; DEET provided 85% protection</td>
</tr>
<tr>
<td>Trongtokit et al,37 2005</td>
<td>PMD (10% and 20%), citronella (40%), DEET (50%)</td>
<td>Arm-in-cage or mosquito-proof room study</td>
<td>Indoors</td>
<td>A stephensi</td>
<td>PMD (20%) provided complete repellency for 7-8 h but PMD (10%) for only 30 min; citronella (40%) protected for 7 h; DEET (50%) protected for 30 h</td>
</tr>
</tbody>
</table>

*See “Personal Protective Measures” section for chemical and alternate names of repellents.
†The only product available in the United States contains low effective concentration.
‡A product containing oils of coconut, jojoba, rapeseed, and vitamin E.
able. Most repellents are water soluble and need to be reapplied frequently when profuse sweating occurs.

No systematic analyses address the safety of long-term use of repellents, though no reports of problems with long-term use have been published. DEET-containing repellents have been widely used since the 1950s, and toxicity is extremely rare and associated with inappropriate rather than prolonged duration of use.26 Moreover, experience with the use of 20% DEET during the second and third trimesters of pregnancy in women on the Thai-Myanmar border with follow-up of infants through 1 year of age demonstrated no increase in adverse neurologic, gastrointestinal tract, or dermatologic effects.27 More recently, DEET-containing products have been sanctioned for use in infants older than 2 months.25,28

The activity of a repellent may not be the same against all species of mosquitoes or against other arthropods, such as ticks. Anopheleines, Aedes, and Culex mosquitoes are important vectors of human pathogens, but only anopheline mosquitoes transmit malaria. One comparison showed that DEET-based products provided the longest protection against Aedes mosquito bites; higher concentrations lasted longer, and 23.8% DEET protected a mean of 5 hours.29 Some recent studies have found picaridin, DEET, and PMD effective against Anopheles mosquitoes.30-37 (TABLE 2).

Because picaridin has a longer half-life after application on skin, it may be particularly useful in areas with high vector densities.33 However, the available products in the United States do not contain the optimal effective concentration and are not currently recommended for prevention of malaria. Long-term travelers also need to be aware of the biting habits of the local Anopheles populations, although this information is not readily available before travel. Anopheles gambiae bites mainly late at night, emphasizing the importance of impregnated bed nets in Africa, whereas A. darlingi (an important vector in the Amazon basin) bites earlier in the evening, suggesting that repellents would be pivotal in this area.36,38-40

TABLE 3 summarizes evidence of benefit regarding personal protective measures.22-24,39,40 However, adherence to personal protective measures such as use of screened accommodations, repellents, insecticides, and bed nets by long-term travelers is suboptimal.41-43 A study evaluating knowledge, attitudes, and practices of travelers found that only 2% of tourists and 3.8% of business travelers adhere to an effective combination of personal protection measures.44 Finally, misconceptions abound about approaches, such as thiamine (vitamin B1), garlic, or ultrasound devices and electronic buzzers, that do not work.45

**Malaria Chemoprophylaxis**

Although personal protective measures and environmental and behavioral modifications can reduce the risk of exposure to infective mosquitoes, these interventions cannot eliminate risk of infection. In combination with these measures, chemoprophylaxis can further reduce the risk of poor outcome if a person is bitten by infective mosquitoes.46 Most chemoprophylactic regimens provide about 75% to 95% protection, even if taken correctly,47 and no chemoprophylactic regimen is 100% effective. Long-term travelers may plan pregnancy while in malarious areas, but malaria during pregnancy is associated with severe consequences to both mother and fetus, and special considerations are needed because some chemoprophylactic drugs are contraindicated during pregnancy (TABLE 4).

**Restrictions on the Duration of Use of Chemoprophylaxis**

In general, the drugs used for chemoprophylaxis have been used widely for many years, though primarily in short-term travelers, and their adverse effects are well known. Concerns arise when these drugs are considered for
prolonged use. The licensing restrictions probably contributed to concerns about long-term use of some chemoprophylactic medications. Table 4 summarizes these restrictions, the clinical data on long-term use, and the duration of use approved by the UK Advisory Committee on Malaria Prevention.3,48-51

Safety of Malaria Chemoprophylaxis for Long-term Travel

Chloroquine has been used in a continuous manner for years by travelers as well as patients with rheumatologic disorders. Retinal toxicity is of concern when a 100-g cumulative dose of chloroquine base is reached, usually after 5 to 6 years of weekly dosing. The UK Advisory Committee on Malaria Prevention recommends ophthalmologic examination every 6 to 12 months after 5 to 6 years of use.3 Similar caution and screening are recommended for hydroxychloroquine.

For areas with chloroquine-resistant malaria, mefloquine is considered a convenient option for long-term chemoprophylaxis due to its simple dosage schedule (once weekly), wide experience (especially from Peace Corps studies in Africa), pharmacokinetic data indicating that drug accumulation does not occur after long-term intake, and good tolerability during prolonged use.48-52,53

Adverse effects of mefloquine have caused concern. The incidence of serious adverse effects associated with mefloquine was previously estimated to be 1 in 6000 to 1 in 10 600.54,55 A double-blind, placebo-controlled study of airline pilots using a flight simulator found that mefloquine was associated with nonserious sleep-related adverse effects but no significant adverse influence on performance.56 Another double-blind study comparing the tolerability of mefloquine, chloroquine-proguanil, doxycycline, and atovaquone-proguanil as chemoprophylactic regimens showed relatively poor tolerability for all regimens, with more than 80% of participants reporting at least 1 adverse event; severe adverse events (ie, those requiring medical attention) were reported in 12% of mefloquine users, compared with 11% with chloroquine-proguanil, 6% with doxycycline, and 7% with atovaquone-proguanil.57 In contrast, mefloquine use among US service members from 2002-2004 was not associated with severe health effects.58 Mefloquine was well tolerated when used for more than 3 months in Italian soldiers in Somalia and Mozambique59 as well as in Peace Corps Volunteers, where it was used for up to 2.5 years.48 Only 0.3% of Dutch marines who used mefloquine for 6 months reported adverse effects requiring medical attention.60 Mefloquine adverse events tend to occur early in prophylaxis; if users initially tolerate mefloquine, they are unlikely to have late-onset adverse events.48

Postmarketing surveillance of the use of atovaquone-proguanil for up to 34 weeks has found some association with gastrointestinal tract adverse events (diarrhea, abdominal pain, mouth ulcers, nausea, vomiting) and neuropsychiatric adverse events (dizziness, insomnia, vivid dreams) in 10% and 8.5% of users, respectively, but only 1% discontinuation (due to diarrhea).61 Australian soldiers deployed to Somalia for 4 months and to Cambodia for 12 months used doxycycline; adverse events led to a medication change in

Table 4. Data on Duration of Use of Malaria Chemoprophylactic Drugs

<table>
<thead>
<tr>
<th>Source</th>
<th>Drug (Proprietary Name)</th>
<th>Licensed Duration in United States</th>
<th>Restrictions on Duration of Use Elsewhere</th>
<th>Longest Published Clinical Use</th>
<th>Safety in Pregnancy</th>
<th>UK ACMP Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lobel et al,49</td>
<td>Chloroquine phosphate</td>
<td>No limit</td>
<td>No limit, but caution in use &gt;5 y</td>
<td>2-2.5 y in Peace Corps Volunteers</td>
<td>Yes</td>
<td>No limit, but retinal toxicity a possible concern when cumulative dose exceeds 100 g; ophthalmologic examination every 6-12 mo after taking chloroquine for &gt;5-6 y</td>
</tr>
<tr>
<td></td>
<td>(Aralen) or hydroxychloroquine sulfate (Plaquenil)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lobel et al,49</td>
<td>Mefloquine (Lariam)</td>
<td>No limit</td>
<td>No limit</td>
<td>2-2.5 y in Peace Corps Volunteers</td>
<td>Yes</td>
<td>Up to 3 y</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overbosch,49</td>
<td>Atovaquone-proguanil</td>
<td>Maximum of 28 d-3 mo (most European countries)</td>
<td>34 wk postmarketing surveillance</td>
<td>Unknown, avoid</td>
<td>At least up to 3 mo, possibly up to ≥6 mo</td>
<td></td>
</tr>
<tr>
<td>(Malarone)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shanks et al,50</td>
<td>Doxycycline (Vibramycin, Doryx, and others)</td>
<td>4 mo</td>
<td>2 y for acne treatment (United Kingdom)</td>
<td>12 mo in Australian Defense Force to Cambodia</td>
<td>Contraindicated</td>
<td>At least up to 2 y</td>
</tr>
<tr>
<td></td>
<td>(Primquine)*</td>
<td>No limit</td>
<td>No limit</td>
<td>52 wk in nonimmune Javanese transmigrants to Papua New Guinea</td>
<td>Contraindicated</td>
<td>No specific recommendation on duration</td>
</tr>
</tbody>
</table>

*Must screen for G6PD deficiency first.
Adherence With Chemoprophylaxis During Long-term Intake

Adherence to chemoprophylaxis in long-term travelers has been poor. The use of malaria prophylaxis in missionaries was dismal, ranging from 19% to 62%, even counting persons who missed doses. Only 38% of expatriate mine workers in Zambia used any chemoprophylaxis; of these, only half took the medication year around. Among expatriate workers at a construction site in Ghana, only 11% continued to take malaria prophylaxis for more than 7 months; half stopped their antimalarial agent or changed to a new agent based on medical advice, adverse effects, a perceived low risk of malaria, or advice of local colleagues. Commonly cited reasons for poor adherence include fear of long-term adverse effects, adverse events from medication, conflicting advice, and complicated regimens or daily medications. Developing malaria while taking chemoprophylactic drugs (ie, “breakthrough” malaria) or having febrile illnesses misdiagnosed as malaria also reduce confidence in chemoprophylaxis.

Different approaches have evolved (Table 5). These include continuing the medication beyond licensed durations, using different chemoprophylactic regimens sequentially, using a regimen such as chloroquine-proguanil that has no time limit but has suboptimal efficacy, and discontinuing chemoprophylaxis in favor of establishing local medical care and stand-by treatment. “Mixing and matching” of antimalarial agents can lead to gaps in protection. This can occur when an individual shifts from one antimalarial agent to a different one because of drug unavailability or adverse reactions or because of travel to regions where parasites have different resistance patterns.

<table>
<thead>
<tr>
<th>Approach</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal protective measures</td>
<td>Effective with minimal toxicity</td>
<td>Cumbersome during a long trip or stay</td>
</tr>
<tr>
<td>Continuous chemoprophylaxis</td>
<td>Most reliable method for medication in high-risk regions</td>
<td>Adverse events from medication</td>
</tr>
<tr>
<td>Seasonal prophylaxis</td>
<td>Best for areas with clear seasons of transmission, knowledgeable and responsible travelers</td>
<td>Must have knowledge of local malaria epidemiology</td>
</tr>
<tr>
<td>Initial prophylaxis followed by SBET</td>
<td>Best for knowledgeable and responsible travelers with long stays in 1 location Traveler has control Less medication</td>
<td>Must arrange local medical care</td>
</tr>
<tr>
<td>SBET</td>
<td>Best for knowledgeable and responsible travelers Traveler has control Less medication Positive risk-benefit analysis for long-term travelers in low-risk areas May be life-saving in certain circumstances Low cost</td>
<td>Must seek medical evaluation for febrile illness</td>
</tr>
<tr>
<td>Combination of seasonal or initial prophylaxis with SBET</td>
<td>Best for knowledgeable and responsible travelers</td>
<td>Requires detailed instructions</td>
</tr>
</tbody>
</table>

Abbreviation: SBET, stand-by emergency treatment.

Table 5. Advantages and Disadvantages of Malaria Prevention Approaches in Long-term Travelers

©2006 American Medical Association. All rights reserved.
recommended SBET for travelers to low-risk malaria areas.\textsuperscript{69}

Much debate regarding SBET ensued. Assessment of Swiss and German travelers who used SBET found 4- to 10-fold overdose.\textsuperscript{70,71} The drugs can have adverse effects and can be inappropriately used for illnesses that require other treatment. Further study of Swiss travelers who were prescribed SBET found that one third of patients ill with malaria-like symptoms did not seek medical attention as advised.\textsuperscript{70} Adherence to SBET guidelines is a recognized problem with the SBET strategy, and travelers need concise oral and written instructions and personalized dosage schedules for family members.\textsuperscript{72} Errors associated with SBET use include changing chemoprophylaxis, ie, the tendency to replace chemoprophylaxis with SBET (11%); lack of confirmation of diagnosis after initiating SBET (23%); lack of medical evaluation (25%); and mistakes with medication (88%).\textsuperscript{71} Self-diagnosis of malaria is unlikely to be correct.\textsuperscript{70,71} Use of SBET can lead to delayed diagnosis of other serious conditions.\textsuperscript{72}

Currently, SBET alone is recommended for Swiss and German travelers to low-risk areas of Asia and Central and South America, while chemoprophylaxis remains the best strategy for travelers going to areas with high \textit{P falciparum} transmission, such as sub-Saharan Africa and Papua New Guinea.\textsuperscript{73} Recently some European experts have also adapted the SBET strategy for travelers to India, because new data on imported malaria from the Indian subcontinent showed a very low risk of infection\textsuperscript{74} and suggested that most imported infections are late-onset \textit{P vivax} infections. In many European countries, atovaquone-proguanil or a fixed combination of artemether-lumefantrine (not available in the United States) are recommended as ideal SBET. Chloroquine can be recommended as SBET only in Central America due to widespread resistance elsewhere. Mefloquine can also be used as a reasonably priced SBET but has been associated with considerable adverse events at therapeutic doses.\textsuperscript{75} Quinine remains an option for pregnant women but has a complicated dosage schedule. Two older medications that were originally recommended for SBET are now contraindicated: sulfadoxine-pyrimethamine (due to fatal adverse events)\textsuperscript{76} and halofantrine (associated with sudden death in travelers due to fatal arrhythmias)\textsuperscript{77} (TABLE 6).

The US Centers for Disease Control and Prevention currently does not recommend SBET alone for travel to low-risk areas but does recommend atovaquone-proguanil for SBET, which applies to high-risk areas where SBET should be considered in addition to chemoprophylaxis in the event a traveler needs to self-treat.\textsuperscript{63} Because of the concern for resistance and additive toxicity, the medication used for SBET should differ from what the traveler uses for chemoprophylaxis.

### Use of Rapid Diagnostic Tests

A major drawback of SBET is the difficulty encountered by travelers in correctly diagnosing a malaria infection. In 1994 it was suggested that trained travelers could use rapid dipstick malaria tests,\textsuperscript{70} and thereafter self-testing has been evaluated in healthy and febrile travelers.\textsuperscript{78,80} Except for one study of UK travelers\textsuperscript{81} in which 91% of participants could successfully perform and interpret the test, the approach has been hampered by technical difficulties on the part of travelers and also by the issues of false-positive and false-negative results. Components of the rapid tests are likely to deteriorate during long-term storage in tropical climates.\textsuperscript{82} These tests currently are not

---

**Table 6. Medications Recommended as Stand-by Emergency Self-treatment (SBET)**

<table>
<thead>
<tr>
<th>Medication (Proprietary Name)*</th>
<th>Adult Dosage</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Artemether-lumefantrine</strong>&lt;br&gt;(20 mg/120 mg)&lt;br&gt;(Riamet; Co-Artem)</td>
<td>80 mg/480 mg, then 80 mg/480 mg in 8 h, then 80 mg/480 mg every 12 h for 2 d (24 tablets over 3 d)</td>
<td>Effective against multiresistant \textit{P falciparum}&lt;br&gt;Rapid parasite and fever clearance&lt;br&gt;Good safety/tolerability profile for children &gt;10 kg</td>
<td>Not available in the United States&lt;br&gt;Short shelf life (&lt;2 y)</td>
</tr>
<tr>
<td><strong>Atovaquone-proguanil</strong>&lt;br&gt;(250 mg/100 mg)&lt;br&gt;(Malarone)</td>
<td>1000 mg/400 mg daily for 3 d (12 tablets over 3 d)</td>
<td>Effective against multiresistant \textit{P falciparum}&lt;br&gt;Good safety/tolerability profile&lt;br&gt;Pediatric dosing available for children &gt;11 kg</td>
<td>Potential for resistance development&lt;br&gt;Not for pregnant women&lt;br&gt;Interaction with paracetamol and metoclopramide</td>
</tr>
<tr>
<td><strong>Mefloquine</strong> (Lariam, 250-mg base; Mephaquin, 250-mg base)</td>
<td>750-mg base, then 500 mg in 12 h (5 tablets in 1 d)</td>
<td>Inexpensive&lt;br&gt;Wide experience&lt;br&gt;Effective against all Plasmodial species&lt;br&gt;Can be used for children &gt;5 kg&lt;br&gt;Can be used in second and third trimesters of pregnancy</td>
<td>Increasing \textit{P falciparum} resistance&lt;br&gt;Neurotoxicity increases at treatment doses (1:216)&lt;br&gt;Negative reports in media</td>
</tr>
<tr>
<td><strong>Chloroquine</strong>&lt;br&gt;(Chlorochin, 150-mg base; Nivaquin, 100-mg base)</td>
<td>600-mg base, then 300 mg in 6 h, 300 mg daily for 2 d (10 tablets over 3 d)</td>
<td>Inexpensive&lt;br&gt;Can be used for children &gt;5 kg&lt;br&gt;Can be used in pregnancy</td>
<td>Widespread resistance&lt;br&gt;Can only be recommended for travelers to Central America and the Caribbean</td>
</tr>
</tbody>
</table>

\*Halofantrine (Halbar) and sulfadoxine-pyrimethamine (Fansidar) are no longer recommended as SBET.
available to travelers in the United States.

**Counterfeit Drugs**
Counterfeit drugs, including antimalarial drugs, are widely distributed, especially in Asia. Long-term travelers are likely to purchase their drugs in the country of temporary residence unless they return frequently to their home country or can arrange shipment or delivery of drugs. Problems with counterfeit drugs include incorrect amount of active ingredient, toxic or allergenic additions to medication, and formulations that may have different pharmacokinetic properties. Long-term travelers must understand these issues and obtain safe, real, and effective medications. A recent report identified at least 12 different counterfeit artemesunate products in circulation in Southeast Asia.

**Seasonal Prophylaxis**
No national or international guidelines recommend using chemoprophylaxis only periodically for long-term travel to areas of malaria risk. However, some long-term travelers prefer this approach over continuous chemoprophylaxis. However, if travelers take chemoprophylaxis only in seasons or locations with higher transmission seasons, they also need access to reliable medical care and SBET. Despite the lack of formal proposal or assessment of seasonal malaria prophylaxis in long-term travelers, the practice may be common among expatriates in some locations. Among the expatriate workers at a construction site in Ghana, 6.3% varied their chemoprophylaxis only in seasons or low-transmission seasons, but unusual weather changes can alter the transmission pattern. Therefore, seasonal malaria prophylaxis should be considered an alternative strategy for only some long-term travelers who clearly understand these complex issues. All long-term travelers should identify medical facilities (and types of services offered) that are available to them locally and regionally.

**Vivax Malaria in Long-term Travelers**
The primary goal of prophylaxis is prevention of severe morbidity and deaths from malaria. Most deaths are from falciparum malaria; vivax malaria, which can be severe, is rarely lethal. However, vivax malaria can have a long latency and present many months after a trip, at a time when the traveler may not recall the exposure. The malaria chemoprophylactic regimens commonly used (chloroquine, doxycycline, mefloquine, atovaquone-proguanil) prevent the blood-stage infection but do not prevent relapses of vivax malaria because they do not eliminate the liver-stage parasites (hypnozoites). Falciparum and vivax are the dominant plasmodial parasites in all malarious areas, though the intensity of transmission and relative proportion contributed by each species varies by geographic area and may change over time. In most countries in sub-Saharan Africa, falciparum causes 85% or more of the malaria cases, yet absolute risk of vivax malaria may be higher than in countries in which vivax malaria accounts for all cases but the level of transmission is low. Approximately one third of vivax malaria cases imported to Europe from 1999 to 2003 and reported to TropNetEurop (http://www.tropnet.eu) followed exposures in sub-Saharan Africa. Although severe complications were rare, 60% of the patients were hospitalized.

Vivax malaria accounts for one quarter to more than one half of malaria cases in travelers in some series and varies depending on the predominant destination. High attack rates of vivax malaria have been reported in short-term travelers after intense exposures, eg, a 50% infection rate was reported among Israeli travelers (taking mefloquine prophylaxis) to Ethiopia. Additionally, more than 60% to 80% of travelers with vivax malaria present at least 2 months after departure from the risk area (late onset), when clinical suspicion for malaria may be low.

In recent years, about one quarter of reported malaria cases in the United States (in US and foreign civilians and US military personnel) were due to P vivax (among cases where species was identified); an additional 2.6% to 3.6% were attributed to P ovale. Countries and regions contributing the largest numbers of vivax malaria cases were (by order of contribution, starting with the region contributing the most cases): Asia (India and Pakistan most often), Africa, Central America and the Caribbean, Mexico, Oceania (primarily Papua New Guinea), and South America. Among the cases of vivax malaria reported to the GeoSentinel database, exposures in Africa accounted for 29.5%; Asia, 27%; Oceania/the Pacific, 19.5%; and the Americas, 16.8%. More detailed global distribution of P vivax is described elsewhere.

Vivax and ovale are the 2 plasmodial species that have dormant forms, ie, hypnozoites, that remain in the liver and can later enter the bloodstream to cause clinical relapses. Korean War soldiers treated with chloroquine for vivax malaria experienced fewer relapses after the addition of primaquine, an 8-aminoquinoline; this was called radical cure. Use of drugs to eradicate incubating liver hypnozoites, also called presumptive antirelapse treatment or terminal prophylaxis, refers to the administration of primaquine to asymptomatic persons after their departure from an area where exposure to P vivax may have occurred and is usually administered during the last 2 weeks of malaria chemoprophylaxis.

©2006 American Medical Association. All rights reserved.
The recommended primaquine dose for antirelapse treatment was recently increased from 15 mg to 30 mg daily for 14 days, because of high failure rates with the lower dose.99 Relapses have been more common in travelers who have visited Papua New Guinea or eastern Indonesia, where the vivax strain (Chesson) appears to be more resistant to drugs.101 The timing and combination with other antimalarial agents appear to be important. A higher cure rate occurred in treating the Chesson strain of P vivax with concurrent administration of primaquine with quinine or chloroquine rather than sequential administration of quinine followed by primaquine.100

For travelers who may have had significant exposure to P vivax (eg, long-term travelers to Papua New Guinea and other areas with substantial vivax transmission), primaquine, 30 mg daily, is currently recommended as antirelapse treatment to be given near the end of the course of chemoprophylaxis. Although data suggest that the combination of primaquine with chloroquine or quinine eradicates hypnozoites, so far there is no evidence that primaquine alone is effective in preventing relapse. Primaquine can generally be started after the traveler has returned home (and is still completing chemoprophylaxis), though travelers need to be advised before departure that they should schedule an appointment on return. Screening for G6PD deficiency is essential before administering primaquine. Some data suggest that a weekly dose of primaquine can be considered (for radical cure, not antirelapse treatment) in patients with mild G6PD (usually the A-variant) deficiency.98 Whether or not returned travelers receive antirelapse treatment, they should be informed of the potential for late relapse and the need to seek medical attention. They should inform their clinicians about their durations of exposures in malarious areas.

### CONCLUSIONS

Long-term travelers to malaria-endemic areas face risk of death, morbidity, and reduced productivity because of malaria. General guidelines are desirable, but recommendations for malaria prevention in long-term travelers must be individualized and should be provided by travel medicine specialists (Table 5). Personal protective measures are paramount. Identification of reliable medical facilities at destinations is crucial for long-term travelers regardless of their malaria prevention strategies, and a number of resources are available to aid in this process (eg, the International Association of Medicine Web site [http://www.iamat.org] and the International Association of Medical Assistance to Travellers Web site [http://www.iamat.org]). Data on safety of chemoprophylaxis drugs show reasonable clinical support for long-term use, particularly for mefloquine. Many long-term travelers use a combination of strategies (Figure). Factors and decisions influencing the choice of ap-

---

**Figure. Algorithm for Malaria Prevention in Long-term Travelers**

1. **Long-term Travelers to Malaria-Endemic Countries**
2. **Assess Malaria Risk**
3. **Identify Reliable Care for Malaria Emergencies**
4. **For All Areas With Significant P vivax Transmission, Consider Presumptive Antirelapse Treatment**

### Categories of malaria risk are defined based on world regions and country-specific risk levels.2,7,8,21,94

### The CDC currently does not recommend SBET alone or seasonal chemoprophylaxis for any malarious areas.†Rapid diagnostic tests for malaria could become an attractive option in occasional circumstances if technical problems are overcome.74-82

---

The algorithm represents the authors’ opinions and not the opinion of official guidelines. The US Centers for Disease Control and Prevention (CDC) recommends consideration of SBET in addition to continuous chemoprophylaxis for travel to areas where self-treatment may be necessary and for travelers taking suboptimal chemoprophylaxis.

©2006 American Medical Association. All rights reserved.
proaches include intensity of transmission, predominant parasite, duration of stay, resistance pattern, host factors, access to care, personal preference, economics, other health issues, and G6PD status. More data are needed to adequately recommend alternatives to current chemoprophylaxis. All travelers should be advised to carry or arrange adequate supplies of antimalarial agents, because counterfeit drugs are rampant in developing countries. Long-term travelers should also consider evacuation insurance for medical emergencies. The components of rapid dipstick tests are likely to deteriorate under tropical conditions, but such tests may be considered for certain travelers at remote locations. Pr presumptive antirelapse therapy should be considered for long-term travelers who have been intensively exposed to P. vivax. Because inconsistent recommendations undermine the adherence to any preventive strategy, national and international experts should strive toward consensus on guidelines for malaria prevention in long-term travelers.

Author Contributions: Study concept and design: Chen, Wilson, Schlagenhauf. Acquisition of data: Chen, Schlagenhauf. Analysis and interpretation of data: Chen, Wilson, Schlagenhauf. Drafting of the manuscript: Chen, Schlagenhauf. Critical revision of the manuscript for important intellectual content: Chen, Wilson, Schlagenhauf. Administrative, technical, or material support: Chen, Schlagenhauf. Study supervision: Schlagenhauf.

Financial Disclosures: Dr Schlagenhauf has received research funding, honoraria for speaking at conferences, and consultancy fees from F. Hoffmann-La Roche Ltd and GlaxoSmithKline. No other disclosures were reported.

Acknowledgment: We thank Monica Parise, MD, Parasitic Diseases Branch, Division of Parasitic Diseases, National Center for Infectious Diseases, US Centers for Disease Control and Prevention, for her thorough review and constructive comments. Dr Parise received no compensation for her contributions.

REFERENCES


4. World Health Organization (WHO). Malaria. In:


37. Burdon J. Use of malarial prophylaxis amongst a