EPIDEMIOLOGY OF MALARIA AMONG UNITED STATES GOVERNMENT PERSONNEL ASSIGNED TO DIPLOMATIC POSTS

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Abstract. The epidemiology of malaria among U.S. government personnel attached to diplomatic posts has not been reported. We reviewed malaria surveillance reports on persons with onset of symptoms between January 1988 and December 2004. Among 684 slide-proven cases, the median age was 36 years. There were 565 (82.6%) cases of Plasmodium falciparum malaria and 56 (8.2%) of P. vivax malaria. A total of 89.9% were infected in Africa and 5.8% were infected in Asia; 95% of the P. falciparum cases originated in sub-Saharan Africa. One-fourth of all cases were reported in 1990–1991. The average annual incidence (per 1,000 personnel) of Plasmodium between 1995 and 1999 was highest in west Africa (8.96), followed by central Africa (8.08), and east Africa (4.27). No or irregular chemoprophylaxis was reported by 58.5%. Among those who indicated regular prophylaxis, 78% took regimens no longer considered adequate. In sub-Saharan Africa, cases were reported in every month. There were three deaths. Prevention of malaria among U.S. Government employees attached to diplomatic posts should particularly focus on those serving in sub-Saharan Africa and malarious areas of Asia.

INTRODUCTION

Malaria is a parasitic disease causing a public health problem in more than 100 countries and threatening roughly 40% of the world’s population. Each year, malaria causes more than 500 million clinical cases and more than three million deaths worldwide. In the United States, there are 1,000–1,500 cases and up to 12 deaths from malaria annually. Many additional cases and deaths are reported in Europe. The World Health Organization estimates 30,000 travelers acquire malaria each year.

There is little published information regarding malaria risk among persons who live or work overseas. Malaria is a significant risk for military personnel deployed to Asia and Africa. United States Peace Corps volunteers and persons that visit friends and relatives in malarious areas, especially in Africa, are at increased risk.

The U.S. Department of State (DOS) Medical Program plays an important role in the prevention and treatment of illness among Foreign Service and other government personnel and their families stationed at overseas diplomatic posts. For patients with suspected or confirmed malaria, data forms are completed by DOS health care providers and sent to the Office of Medical Services of the DOS in Washington, DC. The blood films are forwarded to the Office of Medical Services in Washington, DC. The blood films are reviewed microscopically by a team of technologists experienced in malaria diagnosis as part of a laboratory quality improvement program.

To ensure patient confidentiality, a unique identifier was assigned to each patient. No personal identifiers were entered. Patient demographic characteristics and information on case reports were analyzed using Microsoft (Redmond, WA) Excel® and frequency tables were generated using SAS (Cary, NC) software applications.

Estimates of malaria incidence in African regions were calculated using number of new cases within each region divided by the number of persons assigned to posts during this period. For 1995–1999, the State Department Personnel and Staffing Division provided information on the authorized population at posts with health units for 1997. For 2000–2004, the total population at posts reported by health units for 2002 was used to estimate incidence. The latter included the number of adults and children. Because reporting from southern African posts is incomplete for 2002, the authorized number for 1999 is used.

Definition of terms. The following definitions were used in this report. Laboratory criteria for diagnosis was the demonstration of malaria parasites in blood smears determined to be P. falciparum, P. vivax, P. ovale, P. malariae, or Plasmodium species. A presumptive case is a person with symptoms compatible with malaria and treated without blood smear microscopic confirmation.

METHODS

Project clearance and patient confidentiality. The protocol for the study was prepared as part of the requirements for a Masters in Public Health degree by Priya Joy Rathnam in consultation with Dr. Joe P. Bryan. Prior to accessing State Department medical records, the Office of Medical Services of the DOS reviewed and approved the protocol and the George Washington University Institutional Review Board (IRB) judged the study exempt from IRB review.

Case report forms. A case report form (CRF) for malaria is requested for each case of suspected malaria under the care of the DOS medical program. The CRF contains demographic and laboratory data including the results of the malaria blood smear. Health care providers note clinical symptoms, presence of malaria-associated complications, reported use of chemoprophylaxis, and therapy prescribed.

The CRF, along with blood films, are forwarded to the Office of Medical Services in Washington, DC. The blood films are reviewed microscopically by a team of technologists experienced in malaria diagnosis as part of a laboratory quality improvement program.

RESULTS

Analysis of case characteristics. There were 781 reports of malaria between 1988 and 2004. Of these, there were 97 re-
ports of persons treated presumptively for malaria for whom the malaria smear was negative or not done. These presumptive cases were reported from Africa (85%), were primarily male (65%) and had a median age of 33.7 years. Forty-seven patients reported regular prophylaxis (48%). There was one death in this group, a 67-year-old family member of a government contractor. However, because malaria was not shown microscopically in this group, they will not be considered further. Therefore, there were 684 slide-proven cases of malaria.

Among 684 cases with slide-demonstrated malaria parasites, the median age was 36 years (range = 9 months to 72 years). Most patients (64.8%) were 20–49 years of age, 11.1% were 50–59 years of age, and 2% were ≥ 60 years of age. Children less than five years of age comprised 4.1% and persons 5–19 years of age comprised 13.4%. For 4.5%, the age was not reported. There were 443 male (65%) and 235 female (34%) cases. For six cases, sex was not reported.

Patients with malaria worked for 11 different U.S. government agencies (Table 1). The DOS, along with the U.S. Information Agency, which is now part of the DOS, accounted for 36.3% of cases. Personnel of the U.S. Agency for International Development (USAID) accounted for 30% of cases. Marine Security Guards make up the largest group of military personnel attached to posts and comprised at least 47 of 87 reports among Department of Defense personnel. U.S. Peace Corps staff and their eligible family members receive care from Department of State Health Units and Peace Corps volunteers generally receive care at Peace Corps Health Units.

The peak number of cases reported occurred in 1990 and 1991 (Figure 1). These two years accounted for 172 (25%) of all reports during the 17-year period. There has been a gradual decrease in the number of reports since 1991 when weekly mefloquine was introduced as a recommended regimen for chemoprophylaxis in sub-Saharan Africa.

Plasmodium falciparum infections caused 82.6% of the total cases (Figure 1 and Table 2). Africa and Asia accounted for 95.7% of reported cases (Table 2). West Africa alone reported 42.2% of all cases, followed by east Africa (26.9%) and central Africa (18.4%). In Asia, all cases (5.8% of the total cases) were acquired in south or southeast Asia. Only 2.0% of cases were reported from the Americas and the Australia/South Pacific regions combined.

By Plasmodium species, 95.4% of P. falciparum infections were acquired in Africa, 1.9% in Asia, and 1.6% in the Middle East (Table 2). Among 56 cases of P. vivax, 41% were acquired in Asia, 28.6% in Africa, 14.3% in the Americas, and 7.1% in the Middle East. Cases of Plasmodia that were not further speciated were reported primarily from Africa and Asia. Although most cases were diagnosed and treated in areas endemic for malaria, 19 cases were diagnosed outside malaria-endemic areas.

Incidence of malaria. The estimated incidence of malaria by regions of the world was highest in sub-Saharan Africa (Table 3). The incidence in sub-Saharan Africa (Figure 2) was more than 10 times higher than Asia, the area with the next highest rate. The number of cases and incidence during 2000–2004 was generally lower than 1995–1999. When we combined data from west, central and east Africa, the average incidence for 2000–2004 was higher in adults (average = 6.2/1,000/year) compared with 3.0/1,000/year for children less than 19 years of age.

Seasonality. Of the 610 infections acquired in sub-Saharan Africa over the 17-year period, cases were reported each month of the year, except in southern Africa (Figure 3). Interestingly, the peak of cases in west Africa occurred in January during the dry season. Cases in central, east, and southern Africa paralleled average rainfall (data not shown).

Clinical complications. Complications were reported on 72 (10%) CRFs and included hemolysis (40 cases), mental status changes (10 cases), respiratory symptoms (6 cases), and death (3 cases). Other complications included thrombocytopenia (8 cases), renal failure (2), elevated liver enzyme levels (5), hematemesis (2), hyponatremia (2), and gram-negative sepsis (1).

Three deaths were reported (Table 4). Two were more than 50 years of age (age was not reported for one). Only the Department of Defense employee was part of the DOS medical care system. Two patients reportedly had cerebral malaria. One was taking what is now considered inadequate prophylaxis, one took prophylaxis erratically, and one was not using chemoprophylaxis.

Prophylaxis. Of 684 microscopically proven cases, 58.5% were not taking prophylaxis or were using it on an irregular basis (Table 5). No or irregular use of chemoprophylaxis was

**Table 1**

<table>
<thead>
<tr>
<th>Agency</th>
<th>No. of Cases</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department of State</td>
<td>224</td>
<td>32.7</td>
</tr>
<tr>
<td>U.S. Agency for International Development</td>
<td>205</td>
<td>30.0</td>
</tr>
<tr>
<td>Department of Defense*</td>
<td>88</td>
<td>12.9</td>
</tr>
<tr>
<td>Unofficial†</td>
<td>60</td>
<td>8.8</td>
</tr>
<tr>
<td>U.S. Peace Corps</td>
<td>54</td>
<td>7.9</td>
</tr>
<tr>
<td>United State Information Agency</td>
<td>25</td>
<td>3.6</td>
</tr>
<tr>
<td>Not stated</td>
<td>8</td>
<td>1.2</td>
</tr>
<tr>
<td>Voice of America</td>
<td>7</td>
<td>1.0</td>
</tr>
<tr>
<td>Drug Enforcement Agency</td>
<td>6</td>
<td>0.9</td>
</tr>
<tr>
<td>Centers for Disease Control and Prevention</td>
<td>4</td>
<td>0.6</td>
</tr>
<tr>
<td>Department of Treasury or Justice</td>
<td>3</td>
<td>0.4</td>
</tr>
<tr>
<td>Total</td>
<td>684</td>
<td>100</td>
</tr>
</tbody>
</table>

*Includes one Coast Guard member, 49 Marine Security Guards, 8 Defense Attaché personnel, and 3 attached to a US Naval Medical Research Unit. The other 27 personnel were not further differentiated.
†Persons granted privileges to a health unit by the ambassador including teachers, missionaries, High Commission officers, private contractors, Fulbright scholars, and others.
reported by 57.7% of cases with *P. falciparum* and 83.9% with *P. vivax* malaria.

There were 221 persons who were diagnosed with *P. falciparum* malaria in Africa who indicated they used regular prophylaxis. These regimens included chloroquine alone, 71; chloroquine plus proguanil, 68; chloroquine plus primaquine, 4; pyrimethamine alone or in combination with dapsone or sulfadoxine, 5; doxycycline, 8; proguanil alone, 12; mefloquine, 49; a natural product, 1; or unknown, 3. Therefore, 171 (78%) of the 221 cases were taking chemoprophylaxis regimens that are no longer recommended in Africa to prevent *P. falciparum* malaria. Among those reportedly taking mefloquine, levels were not detectable in one person. Some others may have been taking one tablet every other week as originally recommended.

**Comparison of results of microscopy and relationship to chemoprophylaxis.** Among 677 slides submitted to the Laboratory of the Office of Medical Services in Washington, DC over the 17 years, the Washington laboratory agreed with the local laboratory results for 552 (81.5%), including 486 positive and 66 negative. The Washington laboratory found parasites on 12 (1.8%) read as negative by the local laboratory. However, the major discrepancy was in slides read as positive for malaria parasites by local laboratories that could not be confirmed in Washington (n = 113). The Washington laboratory confirmed malaria parasites less frequently among those reportedly taking mefloquine (23 [51%] of 45 cases) compared with those taking chloroquine-based regimens (105 [87%] of 121 cases; \( P < 0.001 \) by chi-square test).

**DISCUSSION**

This report provides important information on the risk and impact of malaria on U.S. government employees working overseas. It defines who is at risk, the types of *Plasmodium* causing infection, the seasonality of malaria, and the regions of greatest risk. Using post-population data, we estimate the incidence by region and among adults and children. Knowledge of these parameters will improve education of government workers and their medical care providers and provide data for policy makers to formulate prophylaxis strategies. In addition, it highlights the need for better diagnostic testing and continued reporting.

Among 97 cases classified presumptively as malaria without slide-proven malaria, some were likely true cases and were therefore treated appropriately. However, an important alternative diagnosis may have been missed,18 patients may have

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**Table 2**

Cases of malaria by region of exposure, U.S. Department of State, 1988–2004

<table>
<thead>
<tr>
<th>Region</th>
<th>Plasmodium falciparum</th>
<th>P. vivax</th>
<th>P. malariae</th>
<th>P. ovale</th>
<th>P. species</th>
<th>Region total</th>
<th>Region %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Africa</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>396</td>
<td>89.9</td>
</tr>
<tr>
<td>West Africa</td>
<td>255</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>30</td>
<td>289</td>
<td></td>
</tr>
<tr>
<td>Central Africa</td>
<td>110</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>113</td>
<td></td>
</tr>
<tr>
<td>East Africa</td>
<td>163</td>
<td>9</td>
<td>1</td>
<td>1</td>
<td>10</td>
<td>184</td>
<td></td>
</tr>
<tr>
<td>South Africa</td>
<td>11</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Asia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.8</td>
</tr>
<tr>
<td>South Asia</td>
<td>9</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Southeast Asia</td>
<td>2</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Central America</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caribbean, Mexico</td>
<td>1</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>9</td>
<td>1.5</td>
</tr>
<tr>
<td>South Pacific</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>0.3</td>
</tr>
<tr>
<td>Middle East</td>
<td>7</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>15</td>
<td>1.5</td>
</tr>
<tr>
<td>South America</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>12</td>
<td>0.4</td>
</tr>
<tr>
<td>Unknown</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>0.7</td>
</tr>
<tr>
<td>Total</td>
<td>565</td>
<td>56</td>
<td>5</td>
<td>2</td>
<td>56</td>
<td>684</td>
<td>100</td>
</tr>
</tbody>
</table>

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**Table 3**

Average annual incidence of malaria per 1,000 persons at diplomatic posts, 1995–1999 and 2000–2004

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Region</td>
<td>Personnel</td>
<td>Cases</td>
</tr>
<tr>
<td>Central Africa</td>
<td>396</td>
<td>16</td>
</tr>
<tr>
<td>West Africa</td>
<td>1,718</td>
<td>77</td>
</tr>
<tr>
<td>East Africa</td>
<td>1,780</td>
<td>38</td>
</tr>
<tr>
<td>South Africa</td>
<td>860</td>
<td>4</td>
</tr>
<tr>
<td>South Asia</td>
<td>1,620</td>
<td>6</td>
</tr>
<tr>
<td>Southeast Asia</td>
<td>2,583</td>
<td>2</td>
</tr>
<tr>
<td>South America</td>
<td>3,391</td>
<td>1</td>
</tr>
<tr>
<td>Central America/Caribbean</td>
<td>3,734</td>
<td>0</td>
</tr>
<tr>
<td>Middle East</td>
<td>2,488</td>
<td>1</td>
</tr>
<tr>
<td>Unknown</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Total cases</td>
<td>149</td>
<td></td>
</tr>
</tbody>
</table>

* Authorized persons at posts.
† Actual number of persons at posts reported by Health Units.
behave unnecessarily to potentially toxic malaria treatment, and importantly, doubt about the effectiveness of chemoprophylaxis may have been introduced. Definitive diagnosis in resource-poor areas, continued quality improvement, and training of laboratory personnel are urgently needed.\textsuperscript{19,20}

Although male adults were the group most affected by malaria, there were no available data on the distribution of sex, agency, or duration of exposure in the total post-population to make conclusions on infection and demographics. In west, central, and east Africa, the rate of malaria in children from 2000 through 2004 was less than half that of adults. One could theorize that workers who spend much time in the field such as USAID, Peace Corps staff, and agriculture-related Foreign Service personnel would be at greater risk, but data are lacking. Because most deaths from malaria in travelers occur in persons $\geq 50$ years of age, increased education and prompt medical therapy for these persons may help reduce mortality caused by malaria.\textsuperscript{5,21}

Plasmodium falciparum caused 83\% of all cases of malaria reported in the present study. It is also responsible for the greatest number of reported infections worldwide, and causes the highest rate of complications and death.\textsuperscript{22} In contrast to our study, the proportion of cases of \textit{P. falciparum} diagnosed and reported in the United States is lower, but has gradually increased from 30\% at the beginning of the study period to 50\% of the cases diagnosed in 2003 and 2004.\textsuperscript{5,22} Plasmodium vivax comprised 8.1\% of cases in the present study, but 22–24\% of infections reported in the United States in 2003 and 2004. This may reflect the greater number of travelers from the United States to rural areas of Central and South America and the Indian sub-continent where \textit{P. vivax} is more common. Among cases reported in the United States, \textit{P. malariae} and \textit{P. ovale} each make up approximately 3\% of cases annually\textsuperscript{5} but were surprisingly uncommon among government personnel.

In the present study, 89.9\% of cases were reportedly acquired in Africa. The proportion of cases acquired in Africa and diagnosed in the United States has increased from 37\% in 1992 to 61\% in 2004.\textsuperscript{5,23,24} In a recent study, Africa was the site of acquisition of malaria for 91.1\% of European travelers.\textsuperscript{7} The proportion of patients with malaria was highest among those who had traveled to sub-Saharan Africa.\textsuperscript{18} Malaria rates in the present study and among Swedish travelers highlight the risk of malaria in Africa.\textsuperscript{25}

Understanding the predominant species in various parts of the world is important in prescribing the most effective antimalarial prophylaxis. For example, although atovaquone/proguanil is effective in preventing and treating \textit{P. falciparum} infections, it appears to be less effective in preventing or treating \textit{P. vivax} infections.\textsuperscript{26} Likewise, it is not effective in preventing hypnozoite-related relapses of \textit{P. vivax} and \textit{P. ovale} if used alone for treatment.\textsuperscript{27} One of our cases with \textit{P. vivax} acquired in southeast Asia was treated with atovaquone/proguanil. \textit{Plasmodium vivax} then relapsed several weeks later apparently from inadequate treatment for hypnozoites. Therefore, in areas with substantial \textit{P. vivax} or \textit{P. ovale}, primaquine, either as primary or terminal prophylaxis, might be a better choice, after testing for glucose-6-phosphate dehydrogenase.\textsuperscript{28,29}

The number of patients with \textit{P. vivax} who indicated they were not taking prophylaxis highlights two issues with \textit{P. vivax}.

\begin{table}[h]
\centering
\caption{Deaths reported from malaria by diplomatic post health units, 1988–2004}
\begin{tabular}{|c|c|c|c|c|c|}
\hline
Age, years & Sex & Agency\textsuperscript{a} & Status & Date of onset & Location  \\
\hline
52 & Male & DoD & Employee & 1/24/90 & Lilongwe, Malawi  \\
Unknown & Male & Peace Corps\textsuperscript{b} & Volunteer & 4/1/90 & Nairobi, Kenya  \\
65 & Male & Unofficial & Employee & 6/15/97 & Guinea-Bissau  \\
\hline
\end{tabular}
\textsuperscript{a} DoD = Department of Defense.
\textsuperscript{b} Cases of malaria and all deaths among Peace Corps volunteers are officially investigated and recorded by the Office of Medical Services of the US Peace Corps. Peace Corps staff are under the medical program of the Office of Medical Services of the Department of State. In a few posts, there are Joint Peace Corps/Department of State Health Units.
\end{table}
vivax malaria. Cases with *P. vivax* and *P. ovale* malaria often occur weeks to months after leaving a malarious area.\(^\text{11,27}\) Second, and related, terminal prophylaxis or treatment with an 8-aminoquinoline such as primaquine is necessary to prevent late onset or relapses of these malaria.\(^\text{28}\)

The study indicates that malaria cases peaked in the early 1990s among embassy personnel. Many of those cases occurred in Africa as chloroquine resistance developed across this continent.\(^\text{30,31}\) A study in Kampala, Uganda in 1992 in response to more cases among embassy personnel indicated one of the major problems was non-compliance with antimalarial medication.\(^\text{32}\) Furthermore, the study suggested chloroquine alone was no longer effective.\(^\text{32}\) The introduction of weekly mefloquine as the recommended prophylactic medication beginning in 1991\(^\text{33}\) was temporally associated with a major decrease of cases across Africa in government personnel. The addition of atovaquone/proguanil in 2000 and primaquine in 2003\(^\text{34,35}\) provide alternatives to mefloquine and doxycycline in these areas with chloroquine resistance.

Malaria risk in Africa changes seasonally. Although the months with greatest risk can often be predicted on the basis of increased temperature and rainfall, there is risk of malaria in every month in west, central, and east Africa. We speculate the reason for the high number of cases of malaria in January in west Africa may relate to prophylaxis irregularities during the end of year holidays, travel to rural areas, and increased outdoor activity in the dry season.

This study indicates the importance of preventing malaria to avoid complications and death. Cerebral malaria was reported in two of three of those cases with fatal outcomes. Prompt medical attention to those with fever and appropriate therapy are key to prevention of severe complications associated with malaria, especially for *P. falciparum* infections. Use of chemoprophylactic medication also reduces the risk of death.\(^\text{36}\) Additionally, our data confirm that persons more than 50 years of age may be at increased risk for complications including death.\(^\text{5,6}\)

There are probably many reasons for the high numbers of cases of malaria in Foreign Service personnel. The increase in infected *Anopheles* mosquitoes and resistance to insecticides are probably the most important reasons for malaria risk, especially in Africa.\(^\text{7}\) The increase in resistance to chloroquine by *P. falciparum* and more recently by *P. vivax* in other areas is likely another.\(^\text{38}\) The underuse of personal anti-mosquito measures such as effective mosquito repellents, insecticide-impregnated bed nets, and protective clothing may be other contributing factors. Finally, the lack of proper and consistent use of chemoprophylactic measures is strongly suggested by this study.

In 2004, 75% of civilians with imported malaria in the United States had used an inappropriate or no chemoprophylactic regimen.\(^\text{5}\) Likewise, most Foreign Service persons with malaria were not taking regular chemoprophylaxis. Furthermore, in at least one instance, measurement of blood levels detected no mefloquine in someone who claimed regular use of the drug. Primary prevention (avoidance of *Anopheles* mosquito bites) and improved compliance to chemoprophylaxis are key.\(^\text{5,8,15,39}\) Effective, generally well-tolerated regimens of mefloquine, doxycycline, atovaquone/proguanil, and primaquine\(^\text{40–42}\) have replaced ineffective\(^\text{50}\) and less safe prophylactic agents such as sulfadoxine/pyrimethamine\(^\text{42}\) and amodiaquine.\(^\text{43}\)

Although trained health care workers completed case report forms, data on prophylaxis use were self-reported. In general, the use of self-reported data presents limitations for accuracy and validity. Few blood samples from malaria cases reporting use of mefloquine to detect blood drug and metabolite levels were available to confirm compliance and absorption. Study of *P. falciparum* isolates for drug sensitivity may be helpful.\(^\text{44}\) In addition, semi-quantitative information on patient use of personal protective measures (bed nets, insecticides, insect repellent, behavioral measures) as well as chemoprophylaxis may enable better detection of chemoprophylaxis failures and assist with compliance.

Another shortcoming is the lack of information gathered on vulnerable persons such as pregnant women and children. Because of concerns about the potential effects of chemoprophylaxis and the effects of malaria on pregnancy,\(^\text{45}\) additional information should be collected about chemoprophylaxis during pregnancy and pregnancy outcomes after malaria.\(^\text{46}\) Attention should also be given to the prevention of malaria in children of all ages through personal protective measures and an effective chemoprophylactic regimen.\(^\text{47,48}\)

Another limitation is that only 89.5% of the 781 case reports reported to the Office of Medical Services were accompanied by blood smears. Some of these slides were of poor quality making confirmation difficult. A further study limitation is underreporting of cases and missing data on reports. We encourage reporting by giving feedback to providers and promoting the use of an updated form. Calculating incidence is complicated by the fact that the denominator of persons at risk for malaria at posts changes almost daily. The use of the actual number of persons at post as reported by health units monthly is probably a more accurate denominator than personnel authorization.

In conclusion, the study indicates those serving in sub-Saharan Africa are at the highest risk for malaria, especially *P. falciparum*. Many of the cases were taking what we now know was inadequate chemoprophylaxis because of parasite resistance. However, most persons who were infected with
malaria did not take chemoprophylaxis, or took it irregularly. Recent drug development now provides four effective preventive drugs for those serving in Africa. Improved mosquito repellents and permethrin-treated bed nets and clothing are also now available. Continued training of laboratory personnel, ongoing laboratory quality improvement programs, field-adapted diagnostic technologies, and ongoing disease surveillance will improve the diagnosis of malaria. Proper and rapid diagnosis ensures all cases of malaria are promptly treated, cases of febrile illness that are not malaria are further investigated for preventable and treatable causes, and appropriate confidence is placed in properly used chemoprophylactic and personal protective regimens.

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