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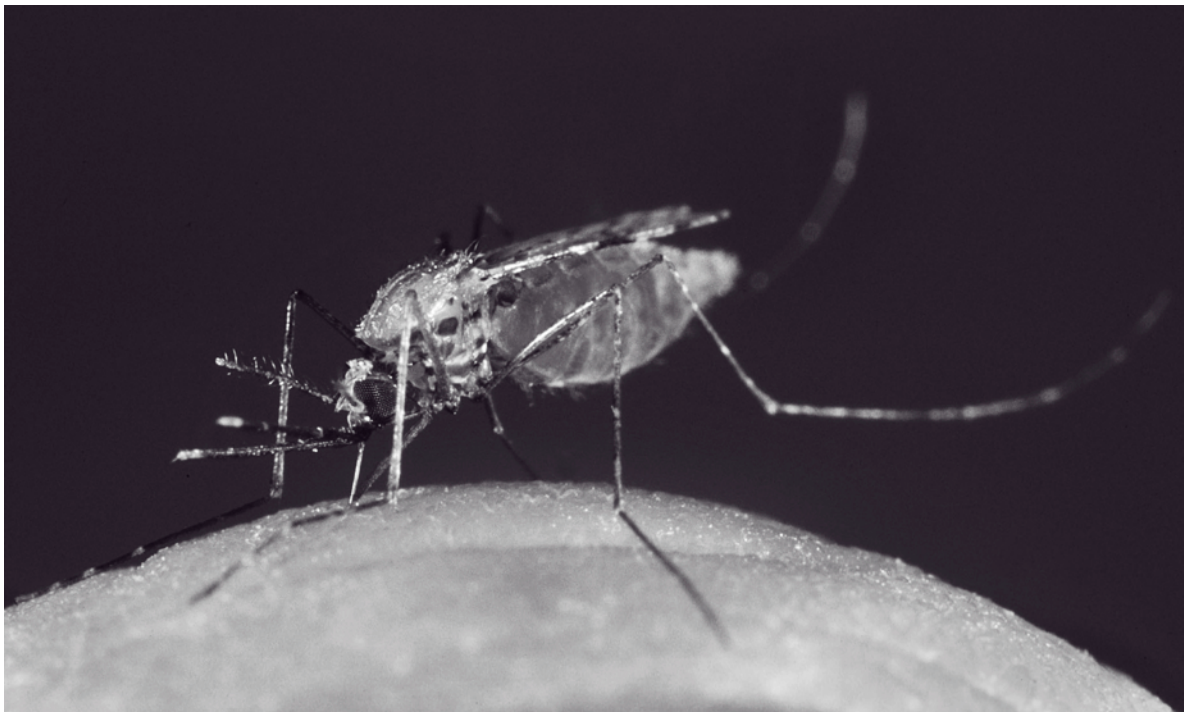
Malaria Surveillance — United States, 2001



DEPARTMENT OF HEALTH AND HUMAN SERVICES
CENTERS FOR DISEASE CONTROL AND PREVENTION

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On the cover: *Anopheles gambiae*, one of the mosquitoes known to transmit human malaria. Source: CDC/James Gathany, CDC/William Brogdon (provider).

Malaria Surveillance — United States, 2001

Scott Filler, M.D.[1,2]
Louise M. Causer, M.B.B.S.[1,2]
Robert D. Newman, M.D.[2]
Ann M. Barber[2]
Jacquelin M. Roberts, M.S.[2]
John MacArthur, M.D.[2]
Monica E. Parise, M.D.[2]
Richard W. Steketee, M.D.[2]
[1]*Epidemic Intelligence Service*
Epidemiology Program Office
[2]*Division of Parasitic Diseases*
National Center for Infectious Diseases

Abstract

Problem/Condition: Malaria is caused by any of four species of intraerythrocytic protozoa of the genus *Plasmodium* (i.e., *P. falciparum*, *P. vivax*, *P. ovale*, or *P. malariae*). These parasites are transmitted by the bite of an infective female *Anopheles* sp. mosquito. The majority of malaria infections in the United States occur among persons who have traveled to areas with ongoing transmission. In the United States, cases can occur through exposure to infected blood products, by congenital transmission, or by local mosquitoborne transmission. Malaria surveillance is conducted to identify episodes of local transmission and to guide prevention recommendations for travelers.

Period Covered: This report covers cases with onset of illness in 2001.

Description of System: Malaria cases confirmed by blood film are reported to local and state health departments by health-care providers or laboratory staff. Case investigations are conducted by local and state health departments, and reports are transmitted to CDC through the National Malaria Surveillance System (NMSS). Data from NMSS serve as the basis for this report.

Results: CDC received reports of 1,383 cases of malaria with an onset of symptoms in 2001 among persons in the United States or one of its territories. This number represents a decrease of 1.4% from the 1,402 cases reported for 2000. *P. falciparum*, *P. vivax*, *P. malariae*, and *P. ovale* were identified in 50.1%, 27.8%, 4.5%, and 3.6% of cases, respectively. Fourteen patients (1.0% of total) were infected by ≥2 species. The infecting species was unreported or undetermined in 179 (12.9%) cases. Compared with 2000, the number of reported malaria cases acquired in Africa increased by 13.2% (n = 886), whereas the number of cases acquired in Asia (n = 163) and the Americas (n = 240) decreased by 31.5% and 11.4%, respectively. Of 891 U.S. civilians who acquired malaria abroad, 180 (20.2%) reported that they had followed a chemoprophylactic drug regimen recommended by CDC for the area to which they had traveled. Two patients became infected in the United States, one through congenital transmission and one whose infection cannot be linked epidemiologically to secondary cases. Eleven deaths were attributed to malaria, 10 caused by *P. falciparum* and one caused by *P. ovale*.

Interpretation: The 1.4% decrease in malaria cases in 2001, compared with 2000, resulted primarily from a decrease in cases acquired in Asia and the Americas, but this decrease was offset by an increase in the number of cases acquired in Africa. This decrease probably represents year-to-year variation in malaria cases, but also could have resulted from local changes in disease transmission, decreased travel to malaria-endemic regions, fluctuation in reporting to state and local health departments, or an increased use of effective antimalarial chemoprophylaxis. In the majority of reported cases, U.S. civilians who acquired infection abroad were not on an appropriate chemoprophylaxis regimen for the country in which they acquired malaria.

Public Health Actions: Additional information was obtained concerning the 11 fatal cases and the two infections acquired in the United States. Persons traveling to a malarious area should take one of the recommended chemoprophylaxis regimens appropriate for the region of travel, and travelers should use personal protection measures to prevent mosquito bites. Any person who has been to a malarious area and who subsequently develops a fever or influenza-like symptoms should seek medical care immediately and report their travel history to the clinician; investigation should include a blood-film test for malaria. Malaria infections can be fatal if not diagnosed and treated promptly. Recommendations concerning malaria prevention can be obtained from CDC by calling the Malaria Hotline at 770-488-7788 or by accessing CDC's Internet site at http://www.cdc.gov/travel.

Introduction

Malaria is caused by infection with one or more of four species of *Plasmodium* (i.e., *P. falciparum*, *P. vivax*, *P. ovale*, and *P. malariae*) that can infect humans. The infection is transmitted by the bite of an infective female *Anopheles* sp. mosquito. Malaria infection remains a devastating global problem, with an estimated 300–500 million cases occurring annually (*1*). Forty-one percent of the world's population lives in areas where malaria is transmitted (e.g., parts of Africa, Asia, the Middle East, Central and South America, Hispaniola, and Oceania) (*1*), and 700,000–2.7 million persons die of malaria each year, 75% of them African children (*2*). In previous decades, malaria was endemic throughout the southeastern United States; an estimated 600,000 cases occurred in 1914 (*3*). During the late 1940s, a combination of improved socioeconomic conditions, water management, vector-control efforts, and case management was successful at interrupting malaria transmission in the United States. Since then, malaria case surveillance has been maintained to detect locally acquired cases that could indicate the reintroduction of transmission and to monitor patterns of antimalarial drug resistance. Anopheline mosquitos remain seasonally present in all states except Hawaii.

Through 2001, the majority of cases of malaria diagnosed in the United States have been imported from regions of the world where malaria transmission is known to occur, although congenital infections and infections resulting from exposure to blood or blood products are also reported in the United States. In addition, a limited number of cases are reported that might have been acquired through local mosquitoborne transmission (*4*).

State and local health departments and CDC investigate malaria cases acquired in the United States, and CDC analyzes data from imported cases to detect acquisition trends. This information is used to guide malaria prevention recommendations for travelers abroad. For example, an increase in *P. falciparum* malaria among U.S. travelers to Africa, an area with increasing chloroquine resistance, prompted CDC to change the recommended chemoprophylaxis regimen from chloroquine to mefloquine in 1990 (*5*).

The signs and symptoms of malaria illness are varied, but the majority of patients experience fever. Other common symptoms include headache, back pain, chills, increased sweating, myalgia, nausea, vomiting, diarrhea, and cough. The diagnosis of malaria should be considered for persons who experience these symptoms and who have traveled to an area with known malaria transmission. Malaria should also be considered in the differential diagnoses of persons who experience fevers of unknown origin, regardless of their travel history. Untreated *P. falciparum* infections can rapidly progress to coma, renal failure, pulmonary edema, and death. Asymptomatic parasitemia can occur, most commonly among persons who have been long-term residents of malarious areas. This report summarizes malaria cases reported to CDC with onset of symptoms in 2001.

Methods

Data Sources

Malaria case data are reported to the National Malaria Surveillance System (NMSS) and the National Notifiable Diseases Surveillance System (NNDSS) (*6*). Although both systems rely on passive reporting, the numbers of reported cases might differ because of differences in collection and transmission of data. A substantial difference in the data collected in these two systems is that NMSS receives more detailed clinical and epidemiologic data regarding each case (e.g., information concerning the area to which the infected person has traveled). This report presents only data regarding cases reported to NMSS.

Cases of blood-film–confirmed malaria among civilians and military personnel are identified by health-care providers or laboratories. Each slide-confirmed case is reported to local or state health departments and to CDC on a uniform case report form that contains clinical, laboratory, and epidemiologic information. CDC staff review all report forms when received and request additional information from the provider or the state, if necessary (e.g., when no recent travel to a malarious country is reported). Reports of other cases are telephoned directly by health-care providers to CDC, usually when assistance with diagnosis or treatment is requested. Cases reported directly to CDC are shared with the relevant state health department. All cases that have been acquired in the United States are investigated, including all induced and congenital cases and possible introduced or cryptic cases. Information derived from uniform case report forms is entered into a database and analyzed annually.

Definitions

The following definitions are used in this report:

- **Laboratory criteria for diagnosis:** Demonstration of malaria parasites in blood films.
- **Confirmed case:** Symptomatic or asymptomatic infection that occurs in a person in the United States who has microscopically confirmed malaria parasitemia, regardless of whether the person had previous episodes of malaria while in other countries. A subsequent episode of

malaria is counted as an additional case if the indicated *Plasmodium* sp. differs from the initially identified species. A subsequent episode of malaria occurring in a person while in the United States could indicate a relapsing infection or treatment failure resulting from drug resistance if the indicated *Plasmodium* sp. is the same species identified previously.

This report also uses terminology derived from the recommendations of the World Health Organization (*7*). Definitions of the following terms are included for reference:

- **Autochthonous malaria:**
- **Indigenous.** Mosquitoborne transmission of malaria in a geographic area where malaria occurs regularly.
- **Introduced.** Mosquitoborne transmission of malaria from an imported case in an area where malaria does not occur regularly.
- **Imported malaria:** Malaria acquired outside a specific area. In this report, imported cases are those acquired outside the United States and its territories (Puerto Rico, Guam, and the U.S. Virgin Islands).
- **Induced malaria:** Malaria acquired through artificial means (e.g., blood transfusion or by using shared common syringes).
- **Relapsing malaria:** Renewed manifestations (i.e., clinical symptoms or parasitemia) of malarial infection that is separated from previous manifestations of the same infection by an interval greater than the usual periodicity of the paroxysms.
- **Cryptic malaria:** An isolated malaria case that cannot be linked epidemiologically to secondary cases.

Microscopic Diagnosis of Malaria

The early diagnosis of malaria requires that physicians consider malaria in the differential diagnosis of every patient who is experiencing fever; the evaluation of such a patient should include taking a comprehensive travel history. If malaria is suspected, a Giemsa-stained film of the patient's peripheral blood should be examined for parasites. Thick and thin blood films must be prepared correctly because diagnostic accuracy depends on blood-film quality and examination by experienced laboratory personnel* (Appendix).

* To obtain confirmation diagnosis of blood films from questionable cases and to obtain appropriate treatment recommendations, contact either your state or local health department or CDC's National Center for Infectious Diseases, Division of Parasitic Diseases, Malaria Epidemiology Branch at 770-488-7788.

Results

General Surveillance

For 2001, CDC received 1,383 malaria case reports occurring among persons in the United States and its territories, representing a 1.4% decrease from the 1,402 cases reported with a date of onset in 2000 (*8*). This incidence is the fifth highest number of reported cases since 1980 and represents the highest number of U.S. civilian cases reported in the previous 30 years (Table 1). In 2001, a total of 891 cases occurred among U.S. civilians, compared with 827 cases reported for 2000, whereas the number of cases among foreign civilians decreased from 354 cases to 316 (Figure 1). Cases

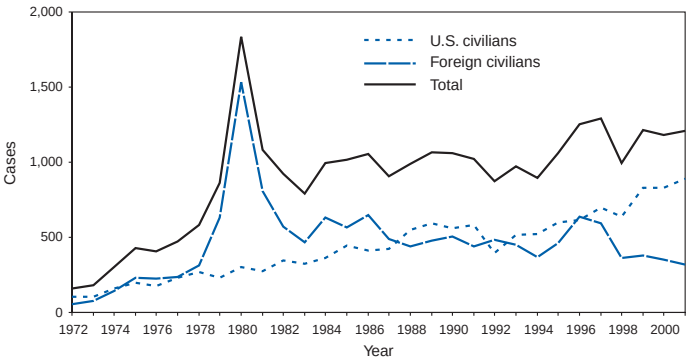
TABLE 1. Number of malaria cases* among U.S. and foreign civilians and U.S. military personnel — United States, 1972–2001

Year	U.S. military personnel	U.S. civilians	Foreign civilians	Status not recorded†	Total
1972	454	106	54	0	**614**
1973	41	103	78	0	**222**
1974	21	158	144	0	**323**
1975	17	199	232	0	**448**
1976	5	178	227	5	**415**
1977	11	233	237	0	**481**
1978	31	270	315	0	**616**
1979	11	229	634	3	**877**
1980	26	303	1,534	1	**1,864**
1981	21	273	809	0	**1,103**
1982	8	348	574	0	**930**
1983	10	325	468	0	**803**
1984	24	360	632	0	**1,016**
1985	31	446	568	0	**1,045**
1986	35	410	646	0	**1,091**
1987	23	421	488	0	**932**
1988	33	550	440	0	**1,023**
1989	35	591	476	0	**1,102**
1990	36	558	504	0	**1,098**
1991	22	585	439	0	**1,046**
1992	29	394	481	6	**910**
1993	278	519	453	25	**1,275**
1994	38	524	370	82	**1,014**
1995	12	599	461	95	**1,167**
1996	32	618	636	106	**1,392**
1997	28	698	592	226	**1,544**
1998	22	636	361	208	**1,227**
1999	55	833	381	271	**1,540**
2000	46	827	354	175	**1,402**
2001	18	891	316	158	**1,383**

* A case was defined as symptomatic or asymptomatic illness that occurs in the United States in a person who has microscopy-confirmed malaria parasitemia, regardless of whether the person had previous attacks of malaria while in other countries. A subsequent attack of malaria occurring in a person is counted as an additional case if the demonstrated *Plasmodium* species differs from the initially identified species. A subsequent attack of malaria occurring in a person while in the United States could indicate a relapsing infection or treatment failure resulting from drug resistance if the demonstrated *Plasmodium* species is the same species identified previously.

† The increase in persons with unknown civil status that occurred in the 1990s might be attributed to a change in the surveillance form.

FIGURE 1. Number of malaria cases among U.S. and foreign civilains — United States,* 1972–2001†



* Includes Puerto Rico, Guam, and the U.S. Virgin Islands.
† The substantial increase in the number of cases reported for 1980 primarily reflects cases diagnosed among immigrants from Southeast Asia

among U.S. military personnel decreased from 46 to 18 in 2001. In 158 cases, information was insufficient to determine civilian or military status.

Plasmodium Species

The infecting species of *Plasmodium* was identified in 1,204 (87.1%) of the cases reported in 2001. *P. falciparum* and *P. vivax* were identified in blood films from 50.1% and 27.8% of infected persons, respectively (Table 2). The 693 *P. falciparum* cases reported for 2001 represented a 13.4% increase from the 611 cases in 2000, whereas the number of *P. vivax* infections decreased by 26.2% (from 522 in 2000 to 385 in 2001). Among 1,149 cases in which both the region of acquisition and the infecting species were known, 76.6% of infections acquired in Africa were attributed to *P. falciparum*; 11.0% were attributed to *P. vivax*. The converse was true of infections acquired in the Americas and Asia: 70.0% and 79.7% were attributed to *P. vivax*, and only 23.8% and 11.9% were attributed to *P. falciparum*, respectively.

TABLE 2. Number of malaria cases, by *Plasmodium* species — United States, 2000 and 2001

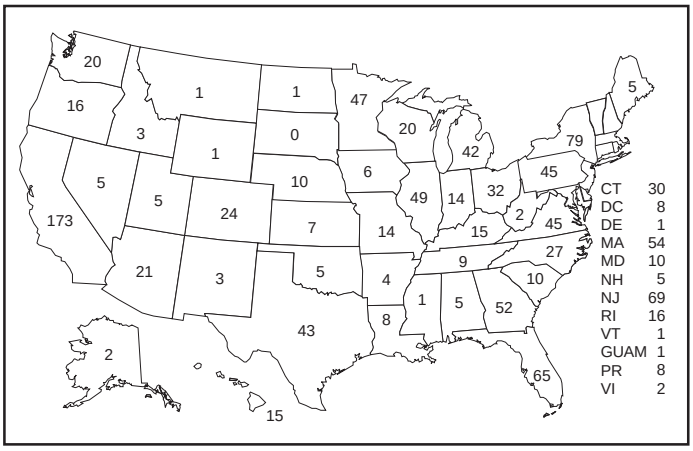
Plasmodium	2000		2001	
Species	**No.**	**(%)**	**No.**	**(%)**
P. falciparum	611	(43.6)	693	(50.1)
P. vivax	522	(37.2)	385	(27.8)
P. malariae	67	(4.8)	62	(4.5)
P. ovale	32	(2.3)	50	(3.6)
Mixed	9	(0.6)	14	(1.0)
Undetermined	161	(11.5)	179	(12.9)
Total	**1,402**	**(100.0)**	**1,383**	**(100.0)**

Region of Acquisition and Diagnosis

All but two of reported cases (n = 1,381) were imported. Of 1,309 imported cases in which the region of acquisition was known, the majority (67.7%; n = 886) were acquired in Africa; 18.3% (n = 240) and 12.5% (n = 164) were acquired in the Americas and Asia, respectively (Table 3). A limited number of imported cases were acquired in Oceania (1.5%; n = 19). The highest concentration of cases acquired in Africa came from countries in West Africa (65.0%; n = 576); a substantial percentage of cases acquired in Asia came from the Indian subcontinent (49.4%; n = 81). From within the Americas, the majority of cases were acquired in Central America and the Caribbean (73.3%; n = 176), followed by South America (17.9%; n = 43). Information regarding region of acquisition was missing for 72 (5.2%) of the imported cases. Compared with 2000, the number of reported malaria cases acquired in Africa increased by 13.2%, and the number of cases acquired in Asia and the Americas decreased by 31.1% and 11.4%, respectively.

In the United States, the five health departments reporting the highest number of malaria cases were New York City (n = 239), California (n = 173), New York State (n = 79), New Jersey (n = 69), and Florida (n = 65) (Figure 2). Whereas the majority of these health departments reported an increase in cases compared with 2000, an overall decrease in cases occurred nationwide. This decrease probably represents year-to-year variation in malaria cases rather than a trend but could also have resulted from local changes in disease transmission, decreased travel to malaria-endemic regions, fluctuation in reporting to state and local health departments, or an increased use of effective antimalarial chemoprophylaxis.

FIGURE 2. Number of malaria cases, by state in which the disease was diagnosed — United States, 2001*



* Excludes New York City.

TABLE 3. Imported malaria cases, by country of acquisition and *Plasmodium* species — United States, 2001

Country of acquisition	*Plasmodium* species						
	P. falciparum	*P. vivax*	*P. malariae*	*P. ovale*	Unknown	Mixed	Total
Africa	**590**	**85**	**48**	**38**	**116**	**9**	**886**
Angola	1	1	0	0	2	0	4
Benin	2	0	0	0	1	0	3
Botswana	2	1	0	0	0	0	3
Burkina Faso	2	0	0	0	2	0	4
Burundi	0	1	0	0	0	0	1
Cameroon	15	3	3	2	2	0	25
Central African Republic	1	0	0	1	0	0	2
Congo	12	0	1	1	1	0	15
Cote d'Ivoire	19	0	1	2	7	0	29
Equatorial Guinea	2	0	0	0	0	0	2
Ethiopia	1	10	1	2	2	0	16
Gabon	1	0	0	0	0	0	1
Gambia	6	2	0	0	1	0	9
Ghana	135	7	10	9	17	1	179
Guinea	10	0	1	0	1	1	13
Kenya	23	12	3	1	9	1	49
Liberia	30	3	0	2	2	0	37
Madagascar	1	4	0	0	2	0	7
Malawi	4	1	1	0	2	0	8
Mali	13	0	1	1	3	0	18
Mauritania	0	2	0	0	2	0	4
Mozambique	5	0	0	0	2	0	7
Nigeria	204	7	11	4	30	2	258
Rwanda	2	2	1	0	0	0	5
Senegal	7	0	1	0	3	0	11
Sierra Leone	8	3	0	1	4	1	17
South Africa	8	0	3	0	0	0	11
Sudan	3	4	0	0	2	0	9
Tanzania	8	2	1	1	3	0	15
Togo	5	0	0	0	0	0	5
Uganda	17	10	0	4	3	1	35
Zambia	4	2	0	1	0	0	7
Zimbabwe	4	0	0	1	1	0	6
West Africa, unspecified	13	1	4	2	5	1	26
Central Africa, unspecified	0	1	0	0	0	0	1
East Africa, unspecified	0	0	1	0	0	0	1
Southern Africa, unspecified	0	0	0	1	1	0	2
Africa, unspecified	22	6	4	2	6	1	41
Asia	**18**	**114**	**6**	**5**	**20**	**1**	**164**
Bangladesh	0	1	0	0	1	0	2
Burma (Myanmar)	0	4	0	0	2	0	6
Cambodia	0	1	0	1	0	0	2
China	2	0	0	0	0	0	2
India	6	60	3	2	9	1	81
Indonesia	7	25	1	1	3	0	37
Iraq	0	1	0	0	0	0	1
Korea (North)	1	0	0	0	0	0	1
Korea (South)	0	4	0	1	3	0	8
Lao PDR	1	1	1	0	0	0	3
Nepal	0	1	0	0	0	0	1
Pakistan	0	11	1	0	2	0	14
Philippines	1	0	0	0	0	0	1
Thailand	0	2	0	0	0	0	2
Yemen	0	2	0	0	0	0	2
Southeast Asia, unspecified	0	1	0	0	0	0	1

TABLE 3. (*Continued*) Imported malaria cases, by country of acquisition and *Plasmodium* species — United States, 2001

Country of acquisition	*Plasmodium* species						
	P. falciparum	*P. vivax*	*P. malariae*	*P. ovale*	Unknown	Mixed	Total
Central America and the Caribbean	**42**	**112**	**1**	**1**	**16**	**4**	**176**
Belize	0	4	0	0	0	0	4
Costa Rica	0	2	0	0	0	0	2
Dominican Republic	2	0	0	1	0	0	3
El Salvador	1	21	0	0	1	0	23
Guatemala	0	30	1	0	6	1	38
Haiti	38	2	0	0	1	0	41
Honduras	1	45	0	0	5	3	54
Nicaragua	0	4	0	0	1	0	5
Panama	0	0	0	0	1	0	1
Central America, unspecified	0	4	0	0	1	0	5
North America	**0**	**15**	**1**	**0**	**5**	**0**	**21**
Mexico	0	15	1	0	5	0	21
South America	**10**	**29**	**2**	**1**	**1**	**0**	**43**
Argentina	0	0	0	0	1	0	1
Brazil	1	2	0	1	0	0	4
Ecuador	3	16	2	0	0	0	21
Guyana	4	4	0	0	0	0	8
Peru	1	4	0	0	0	0	5
Venezuela	0	1	0	0	0	0	1
South America, unspecified	1	2	0	0	0	0	3
Oceania	**4**	**11**	**0**	**0**	**4**	**0**	**19**
Papua New Guinea	4	11	0	0	3	0	18
Vanuatu	0	0	0	0	1	0	1
Europe/Newly Independent States	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Unknown	**29**	**18**	**3**	**5**	**17**	**0**	**72**
Total	**693**	**384**	**61**	**50**	**179**	**14**	**1381**

Interval Between Arrival and Illness

The interval between date of arrival in the United States and onset of illness and the infecting *Plasmodium* species were known for 678 (49.0%) of the imported cases of malaria (Table 4). Symptoms began before arrival in the United States for 98 (14.5%) persons, whereas symptoms began after arrival in the United States for 580 (85.5%) of these patients. Clinical malaria developed within 1 month after arrival in 351 (76.7%) of the 452 *P. falciparum* cases and in 55 (33.3%) of the 165 *P. vivax* cases (Table 4). Only 10 (1.5%) of the 678 persons became ill >1 year after returning to the United States.

Imported Malaria Cases

Imported Malaria Among U.S. Military Personnel

In 2001, a total of 18 cases of imported malaria was reported among U.S. military personnel. Of the 14 cases for whom information regarding chemoprophylaxis use was available, three patients were not using any prophylaxis.

Imported Malaria Among Civilians

A total of 1,207 imported malaria cases were reported among civilians. Of these, 891 (73.8%) cases occurred among U.S. residents, and 316 (26.2%) cases occurred among residents of

TABLE 4. Number of imported malaria cases, by interval between date of arrival in the country and onset of illness and *Plasmodium* species* — United States, 2001

Interval (days)	*P. falciparum*		*P. vivax*		*P. malariae*		*P. ovale*		Mixed		Total	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)
<0†	67	(14.8)	22	(13.3)	5	(13.5)	2	(11.1)	2	(33.3)	**98**	**(14.5)**
0–29	351	(77.7)	55	(33.3)	21	(56.8)	6	(33.3)	3	(50.0)	**436**	**(64.3)**
30–89	25	(5.5)	37	(22.4)	3	(8.1)	6	(33.3)	1	(16.7)	**72**	**(10.6)**
90–179	5	(1.1)	27	(16.4)	6	(16.2)	2	(11.1)	0	0	**40**	**(5.9)**
180–364	2	(0.4)	17	(10.3)	1	(2.7)	2	(11.1)	0	0	**22**	**(3.2)**
≥365	2	(0.4)	7	(4.2)	1	(2.7)	0	(0)	0	0	**10**	**(1.5)**
Total	**452**	**(100.0)**	**165**	**(100.0)**	**37**	**(100.0)**	**18**	**(100.0)**	**6**	**(100.0)**	**678**	**(100.0)**

* Persons for whom *Plasmodium* species, date of arrival in the United States, or date of onset of illness is unknown are not included.
† Persons in these cases in this row are those with onset of illness before arriving in the United States.

other countries (Table 5). Of the 891 imported malaria cases among U.S. civilians, 634 (71.2%) had been acquired in Africa, an increase of 14.2% from cases reported in 2000. Asia accounted for 103 (11.6%) cases of imported malaria among U.S. civilians, and travel to the Central American and Caribbean regions accounted for an additional 92 (10.3%) cases. Of the 316 imported cases among foreign civilians, the majority of cases were acquired in Africa (n = 188; 59.5%).

Antimalarial Chemoprophylaxis Use

Chemoprophylaxis Use Among U.S. Civilians

Information concerning chemoprophylaxis use and travel area was known for 815 (91.5%) of the 891 U.S. civilians who had imported malaria. Of these 815 persons, 487 (59.8%) had not taken any chemoprophylaxis, and 122 (15.0%) had not taken a CDC-recommended drug for the area visited (*9*). Only 180 (22.1%) U.S. civilians had taken a CDC-recommended medication (*9*). Data for the specific drug taken were missing for the remaining 26 (3.2%) travelers. A total of 124 (68.9%) patients on CDC-recommended prophylaxis had taken mefloquine weekly; 28 (15.6%) had taken doxycycline daily; and 12 (6.7%) who had traveled only in areas where chloroquine-resistant malaria has not been documented had taken chloroquine weekly. Sixteen patients (8.9%) had taken combinations of drugs that included ≥1 CDC-recommended drug for the travel region. Of the 122 patients taking a nonrecommended drug, 61 (50.0%) reported taking chloroquine either alone or in combination with another ineffective drug during travel to an area where chloroquine resistance has been documented.

Malaria Infection After Recommended Prophylaxis Use

A total of 200 patients (i.e., 180 U.S. civilians, eight persons in the U.S. military, five foreign civilians, and seven persons whose information regarding their status was missing) experienced malaria after taking a recommended antimalarial drug for chemoprophylaxis. Information regarding infecting species was available for 176 (88.0%) patients taking a recommended antimalarial drug; the infecting species was undetermined for the remaining 24.

Cases of P. vivax or P. ovale After Recommended Prophylaxis Use. Of the 200 patients who experienced malaria after recommended chemoprophylaxis use, 74 cases (37.0%) were caused by *P. vivax* and 14 (7.0%) by *P. ovale*. Notes on the malaria case surveillance reports indicated that 21 (23.9%) of these 88 patients were noncompliant with antimalarial prophylaxis.

A total of 32 (33.7%) cases of *P. vivax* or *P. ovale* occurred >45 days after arrival in the United States. These cases were consistent with relapsing infections and, thus, do not indicate primary prophylaxis failures. Information was insufficient, because of missing data regarding symptom onset or return date, to assess whether 40 cases were relapsing infections. Sixteen cases, 15 by *P. vivax* and one by *P. ovale*, occurred ≤45 days after the patient returned (n = 13) or before return (n = 3) to the United States. Of these 16 patients, four were known to be noncompliant with their antimalarial chemoprophylaxis. Region of acquisition varied for the 12 remaining case-patients who were not known to be noncompliant (three from West Africa, one from Central Africa, three from Central America, four from Asia, and one from Papua New Guinea). Serum drug levels were available for the patient who had traveled to Papua New Guinea. The patient had reported taking mefloquine for prophylaxis, but serum drug levels were undetectable, thus indicating either noncompliance with the recommended regimen or malabsorption of the drug. Blood samples were not available for the remaining 11 cases; serum drug levels were not measured for any of these patients. The probable explanations for these cases are either inappropriate dosing or noncompliance that was not reported. Evidence is

TABLE 5. Number of imported malaria cases among U.S. and foreign civilians, by region of acquisition — United States, 2001*

Area or region	United States		Foreign		Total	
	No.	(%)	No.	(%)	No.	(%)
Africa	634	(71.2)	188	(59.5)	822	(68.1)
Asia	103	(11.6)	42	(13.3)	145	(12.0)
Central America and the Caribbean	92	(10.3)	56	(17.7)	148	(12.3)
South America	29	(3.3)	12	(3.8)	41	(3.4)
North America	7	(0.8)	13	(4.1)	20	(1.7)
Oceania	19	(2.1)	0	(0)	19	(1.6)
Europe/Newly Independent States	0	(0)	0	(0)	0	(0)
Unknown†	7	(0.8)	5	(1.6)	12	(1.0)
Total	**891**	**(100.0)**	**316**	**(100.0)**	**1,207**	**(100.0)**

* Persons for whom U.S. or foreign status is not known are excluded.
† Region of acquisition is unknown.

lacking that would indicate any new area of chloroquine-resistant *P. vivax*.

Cases of P. falciparum and P. malariae after Recommended Prophylaxis Use. The remaining 112 cases of malaria reported among persons who had taken a recommended antimalarial drug for chemoprophylaxis include 74 cases of *P. falciparum*, nine cases of *P. malariae*, five cases of mixed infection, and 24 cases in which the infecting species was unidentified.

A total of 64 of the 74 *P. falciparum* cases among those who reported taking a recommended antimalarial drug was acquired in Africa, six in the Caribbean, two in Asia, and two in Oceania. In 27 (36.5%) of these 74 cases, noncompliance with antimalarials was reported. Of the remaining 47 cases of *P. falciparum* for which patient compliance was unknown, the majority was acquired in Africa (n = 38): 25 in West Africa, four in southern Africa, four in East Africa, two in Central Africa, and three in an unspecified African region. Nine cases were acquired outside Africa: six in the Caribbean (Haiti) and three others (Indonesia, Papua New Guinea, and an unspecified region). Serum drug levels were not available for any of these 47 patients.

Eight of the nine *P. malariae* cases among those who reported taking a recommended antimalarial drug were acquired in Africa. In two (22.2%) of these nine cases, noncompliance with antimalarials was reported. In the seven remaining cases, whether the patient complied with prophylaxis was unknown; six had traveled in Africa, and one in Central America.

Purpose of Travel

Purpose of travel to malaria-endemic areas was reported for 678 (76.1%) of the 891 U.S. civilians with imported malaria (Table 6). Of the U.S. civilians with malaria, the largest percentage (37.4%) were persons who had visited friends or relatives in malarious areas; the second and third highest percentages, 10.6% and 9.2%, had traveled for tourism and to do missionary work, respectively.

Malaria During Pregnancy

A total of 22 cases of malaria was reported among pregnant women in 2001, representing 5.0% of cases among women. Seven of the 22 (31.8%) were among U.S. civilians. Four of these seven women had traveled to visit friends and relatives; six had traveled in Africa, and one in Asia. Only four pregnant women of 22 (18.1%) reported taking prophylaxis, compared with 31.3% of nonpregnant women.

TABLE 6. Number of imported malaria cases among U.S. civilians, by purpose of travel at the time of acquisition — United States, 2001

Category	Imported cases	
	No.	(%)
Visiting friends/relatives	333	(37.4)
Tourism	94	(10.5)
Missionary or dependent	82	(9.2)
Business representative	50	(5.6)
Student/teacher	44	(4.9)
Peace Corps volunteer	21	(2.4)
Refugee/immigrant	3	(0.3)
Air crew/sailor	0	(0)
Other/mixed purpose	51	(5.7)
Unknown	213	(23.9)
Total	**891**	**(100.0)**

Malaria Acquired in the United States

Congenital Malaria

One case of congenital malaria was reported in 2001 and is described in the following case report:

- **Case 1.** In March 2001, a previously healthy infant aged 2 months was admitted to a hospital with a history of fevers. On examination, the baby was febrile, but otherwise appeared well. Laboratory results were significant for intaerythrocytic parasites consistent with *P. vivax*. The infant was treated with oral chloroquine and primaquine and recovered without complications. The infant had been born via normal spontaneous vaginal delivery to a mother who was a native of Pakistan. The mother reported a history of untreated malaria in December 1999, acquired while living in Pakistan. Her symptoms subsided, and she traveled to the United States in October 2000 to visit relatives. She suffered another episode of vivax malaria in November 2000 and because she was pregnant at the time, received only chloroquine. Ten days after delivery in January 2001, she again experienced fevers and a relapse of vivax malaria was diagnosed. She was treated at that time with chloroquine and primaquine.

Cryptic Malaria

One case of cryptic malaria was reported in 2001 and is described in the following case report:

- **Case 1.** On August 15, 2001, a female aged 70 years with a previous medical history notable for congestive heart failure, asthma, upper gastrointestinal bleeding, and a cardiac pacemaker was admitted to a hospital with a 1-week history of weakness, lethargy, anorexia, and dizziness. The patient reported no recent international travel. She had received 3 units of packed red blood cells and 4 units of fresh frozen plasma (FFP) during a previous

hospitalization in July of the same year. At that time, she was treated for upper gastrointestinal bleeding caused by a Mallory-Weiss tear, esophagitis, and two gastric ulcers. She reported no other risk factors for malaria (e.g., intravenous drug use or organ transplant). On physical examination, she was drowsy but arousable. She was febrile (103°F), hypotensive (blood pressure: 80/60 mmHg), and had mildly decreased oxygen saturation (95%). Pertinent laboratory results included anemia (hemoglobin: 9.6 g/dL) and a normal platelet count. Sepsis was initially diagnosed and she was started on intravenous levofloxacin and vancomycin. Her admission complete blood count subsequently was reviewed and demonstrated *P. malariae*. CDC confirmed the diagnosis as *Plasmodium* sp. but was unable to confirm the species. She responded well to treatment with chloroquine. Serological testing of all three of the packed red blood cell donors and two of the four FFP donors did not indicate malaria. Testing of two of the FFP donors was not possible because they did not cooperate with the trace-back investigation.

Deaths Attributed to Malaria

Eleven deaths attributable to malaria were reported in 2001 and are described in the following case reports:

- **Case 1.** On January 11, 2001, a male aged 12 years was taken to a clinic with a 2-day history of fever with chills, malaise, fatigue, cough, and one episode of vomiting. The patient had been born in Nigeria, had emigrated to the United States in 1991, and had returned to Nigeria for 3 weeks in December 2001. The patient and five other family members had been prescribed weekly chloroquine for malaria chemoprophylaxis. A physical examination was notable only for an elevated temperature (102°F). An upper respiratory tract infection complicated by nausea and vomiting was diagnosed, and the patient was prescribed an oral cephalosporin and an antiemetic agent. The symptoms continued, and on January 14, the patient collapsed, was transported to a local hospital, and died in the emergency department shortly thereafter. Examination of a peripheral blood film on stored blood from January 11 and a film from blood taken January 14 demonstrated *P. falciparum* parasites with 0.8% and 14.0% parasitemia, respectively (*10*).
- **Case 2.** On January 18, 2001, a male U.S. resident aged 62 years was admitted to a hospital. He had been found in a nearby airport with an altered mental status after disembarking from an intercontinental flight from Ghana; how long he had stayed in Ghana is not known, nor whether he had taken malaria chemoprophylaxis. In the emergency department, his examination was remarkable for elevated temperature (103°F) and decreased mental status (Glasgow coma scale = 9). Laboratory examination demonstrated decreased bicarbonate (12 mmol/L), increased blood urea nitrogen (BUN) (58 mg/dL) and creatinine (4.4 mg/dL), and thrombocytopenia (44,000/mm^3). He subsequently had a seizure in the emergency department. He was treated with antiepileptics, endotracheally intubated, and placed on mechanical ventilation. A blood film taken in the emergency department revealed *P. falciparum* (12.6% parasitemia); treatment with intravenous quinidine and doxycycline was initiated, and an exchange transfusion was performed. The patient's clinical course was complicated by cerebral malaria and anemia as well as decreased cardiac function (necessitating therapy with vasopressors) and increasing metabolic acidosis. He died <24 hours after admission. No autopsy was performed.
- **Case 3.** On March 19, 2001, a female aged 47 years was admitted to a hospital emergency department with a 2-day history of headaches and dark urine. The patient had returned to the United States after 11 days in East Africa. Chloroquine was taken before and during the trip, and proguanil was added on arrival in Africa. On admission, the physical examination was notable only for an elevated temperature (102°F). A thick blood film obtained initially was read as positive for malaria of unclear species (*P. falciparum* versus *P. malariae*), and later was confirmed as *P. falciparum*. The patient was admitted and treated with oral quinine and doxycycline; however, she experienced cerebral edema and respiratory failure and died 6 days after admission (*10*).
- **Case 4.** On April 6, 2001, a female U.S. resident aged 39 years was admitted to a hospital with a 1-week history of intermittent fevers. She had one episode of fevers, rigors, malaise, and anorexia during a return plane flight multiple years earlier but did not seek medical care at that time. During the ensuing 4 years, she had paroxysms of fevers, but malaria was never diagnosed. The patient's previous medical history was notable for multiple sclerosis. She had lived two summers in Cameroon in the mid-1980s and last traveled to a malarious areas (South Africa, Botswana, and Zimbabwe) 4 years before the onset of this illness. During that 16-day trip, she was taking an unknown prophylaxis. Upon admission, she had a complete blood count notable for thrombocytopenia (platelets: 54,000/mm^3). The malaria blood film was positive for *P. ovale.* The patient was started on quinine sulfate and doxycycline. On the third day of hospitalization, the

patient suffered a cardiac arrest. She was resuscitated, placed on mechanical ventilation, and transferred to the intensive care unit. The patient was severely hypoxic, acidotic, hypotensive, and tachycardic. A hemoglobin taken after the arrest revealed severe anemia (hemoglobin:1.8 g/dL). She was transfused with packed red blood cells, and her antimalarial was switched to intravenous quinidine. During the next few days, the patient experienced renal failure and an ileus thought to be secondary to severe hypoperfusion. Imaging performed after the patient stabilized revealed a ruptured spleen. The patient died on hospital day five.

- **Case 5.** On May 20, 2001, a male aged 62 years was admitted to a hospital with a 3-day history of malaise, dizziness, nausea, fevers, and sweats. On the day of admission, he also complained of severe abdominal pain. Ten days before the onset of his symptoms, he had returned from a 6-day business trip to Togo. He had departed for Africa on short notice, and as a consequence, chemoprophylaxis against malaria was not taken. On admission, the patient was alert and oriented. The physical examination was only notable for tachycardia and vague abdominal tenderness. Laboratory results revealed thrombocytopenia (platelets:71,000/mm^3) and an elevated creatinine (creatinine:1.6 mg/dL). A blood film demonstrated 10% parasitemia with *P. falciparum*. The patient was initially treated with oral quinine and tetracycline. On the day after admission, the treatment was changed to intravenous quinidine and doxycycline, and he was transferred to the intensive care unit, where an exchange transfusion was performed. He experienced progressive dyspnea necessitating endotracheal intubation and mechanical ventilation. Despite apparently successful antimalarial treatment (last blood film on the day before death revealed 0.01% parasitemia), his clinical condition deteriorated. He experienced severe metabolic acidosis and hypotension requiring vasopressors, worsening hepatic and renal function, and disseminated intravascular coagulation. His course was complicated by a perforated duodenal ulcer requiring an emergency laparotomy 2 days after admission, at which time a splenectomy was also performed. Three days after admission he suffered an episode of pulseless ventricular tachycardia, from which he was successfully resuscitated. His clinical condition continued to decline, and he died 5 days after admission.
- **Case 6.** On September 1, 2001, a man aged 46 years was examined in an emergency department for a 5-day history of high fevers, nausea, vomiting, and diarrhea. The patient had returned 15 days before the onset of symptoms from a 6-week trip to Nigeria. He had been prescribed mefloquine for malaria chemoprophylaxis, but he discontinued the medication after 1 dose because of vomiting. The patient had been examined at an outpatient clinic the day the symptoms began, where he had a temperature of 106°F. A viral syndrome was diagnosed, and he was administered antipyretics and sent home. He continued to have high spiking fevers and took 1 dose of mefloquine at home. He was examined again at the outpatient clinic 3 days later and was sent home, where he continued to have fevers and gastrointestinal symptoms. Two days later, he began complaining of abdominal pain and was told by a physician to go to the hospital. In the emergency department, the patient was tachycardic and hypotensive but afebrile. He was weak and had mild abdominal tenderness but had an otherwise normal physical examination. Laboratory findings included acidosis (bicarbonate: 19 mmol/L), elevated BUN (50 mg/dL) and creatinine (2.4 mg/dL), elevated bilirubin (1.9 mg/dL), low calcium (7.7 mg/dL), and thrombocytopenia (platelets: 37,000/mm^3). A malaria blood film demonstrated 10%–15% parasitemia with *P. falciparum*. He was admitted to the intensive care unit with diagnoses of malaria, dehydration, and renal insufficiency. Although intravenous quinidine was initially ordered, the stock in the pharmacy was expired, and quinidine was ordered from a nearby hospital. Six hours after admission to the emergency department, the patient received a first dose of oral quinine. Four hours later, a maintenance dose of IV quinidine was initiated; the first dose of doxycycline was administered on the second hospital day. The patient had respiratory distress on the second hospital day and was endotracheally intubated and placed on mechanical ventilation. The patient refused a recommended exchange transfusion, experienced hypotension and bradycardia, and died on the third hospital day.
- **Case 7.** On September 4, 2001, a man aged 46 years was examined at an emergency department; he had been complaining of myalgias and fever for 2 days. The patient had returned from Senegal 10 days earlier after visiting friends and relatives. The patient had not taken malaria chemoprophylaxis. The diagnosis of malaria was considered, and the patient was admitted. The initial history, physical exam, and laboratory values were notable only for elevated temperature (102°F) and tachycardia. Admission laboratory tests revealed mild anemia (hemoglobin: 12.4 g/dL). During the first 2 hospital days, the patient was managed with antipyretics and intravenous fluids. On the morning of September 6, the laboratory reported a thick film demonstrating P. *falciparum*. An order for oral quinine and doxycycline was placed 8 hours later. On hospital

day 4, the patient suffered acute respiratory distress requiring endotracheal intubation, was transferred to the intensive care unit, and was placed on mechanical ventilation. Antimalarial therapy was continued in the intensive care unit by nasogastric tube. The patient's clinical course deteriorated and was complicated by renal failure, hepatic dysfunction, and circulatory collapse. The patient died on hospital day 11.

- **Case 8.** On September 10, 2001, a man aged 79 years with multiple medical problems was admitted to an emergency department complaining of fevers, dysuria, and weakness. The patient had complained of progressive fatigue earlier that summer. On examination by his oncologist on August 30, 2001, the patient was found to have gross hematuria and low hemoglobin (7.4 g/dL) and was admitted for a transfusion of 3 units packed red blood cells. The hematuria was attributed to stage 4 prostate cancer. After feeling improved, the patient returned home; oncologic follow-up was proposed. The patient was examined again at the emergency department 10 days later. In April of the same year, the patient had returned from a 10-day business trip to China. Malaria chemoprophylaxis was not taken. In the emergency department, a urinary tract infection was clinically diagnosed, and the patient was admitted for antibiotics and observation. On hospital day 4, a hematologic consult was obtained to determine the cause of the patient's thrombocytopenia (platelets: 51,000/mm^3). The hematologist noted *P. falciparum* on blood film and prescribed quinine and doxycycline. The next day, the patient's clinical course deteriorated, and he was transferred to the intensive care unit for monitoring of altered mental status. The patient died soon after transfer to the intensive care unit.

  An investigation of the transfused 3 units of blood by the blood service did not reveal a donor with a history of foreign travel or febrile illness. The blood service did not believe a causal relation between the transfusion and the malaria could be established. No malaria blood film was performed on the patient's blood from the August 30, 2001, hospitalization.
- **Case 9.** On November 13, 2001, a male member of the U.S. military aged 35 years was examined at an emergency department after transfer from an overseas military clinic with suspected malaria. He had arrived for duty in Nigeria on October 9, 2001, and reported taking mefloquine for malaria prophylaxis before and during his duty assignment in Nigeria. One month after arrival, the patient experienced a headache, followed one day later by fever, chills, sweats, blurry vision, diarrhea, and malaise. Three days after the onset of symptoms, he was airlifted out of Nigeria. Physical examination upon arrival was unremarkable except for mild temperature elevation (99.8°F). Laboratory examination revealed thrombocytopenia (21,000/mm^3), and intraerythrocytic ring forms consistent with *P. falciparum*. He was treated with a single dose of quinine and doxycycline, and transferred to another hospital. At the second hospital, laboratory examination revealed 8% parasitemia. He was admitted, and treatment with quinine and doxycycline was continued; an interval of >20 hours elapsed between the first and second doses of antimalarials administered at the two hospitals. One day after admission, he was clinically improving when he complained of chest pain. Hours later, he complained of acute dyspnea and was found unresponsive in cardiac arrest. He was successfully resuscitated, but suffered a second cardiac arrest approximately 2 hours later and died. Postmortem examination revealed a substantial embolus in the right pulmonary artery and a clot in his right femoral and internal iliac veins.
- **Case 10.** On November 18, 2001, a woman aged 38 years was brought by medics to an emergency department obtunded. She had been examined 2–3 days previously at an ambulatory care clinic where new onset diabetes mellitus (glucose: >500 mg/dL) was diagnosed. No further information regarding her symptoms leading to the ambulatory visit were available. The patient had traveled to Haiti for 3 weeks and returned to the United States approximately 6 weeks before examination. The patient reportedly did not take malaria chemoprophylaxis. Examination in the emergency department revealed fever (temperature: 101°F), tachycardia (heart rate: 101 beats per minute), and altered mental status. The remainder of the physical examination was unremarkable. Initial laboratory findings included thrombocytopenia (platelets: 15,000/mm^3), mild anemia (hemoglobin: 11.3 g/dL), elevated BUN (80 mg/dL), creatinine (2.6 mg/dL) and glucose (754 mg/dL). She was admitted to the intensive care unit with a diagnosis of sepsis, diabetic ketoacidosis, and altered mental status. Two days after admission, malaria parasites consistent with *P. falciparum* were noted on a routine blood examination (13% parasitemia), and therapy with intravenous quinidine gluconate was initiated. One day later, her clinical condition deteriorated. She was placed on mechanical ventilation, and was being prepared for an exchange transfusion when she suffered a cardiac arrest and died. No autopsy was performed.
- **Case 11.** On November 23, 2001, a woman aged 39 years was examined at an emergency department with a history of a near-syncopal episode. She reported a 1-week history of chills, headaches, myalgias, and fatigue, and a 4–5 day

history of diarrhea, nausea, and vomiting. One week before examination, the patient had returned from 2 years as a Peace Corps volunteer in Ghana, which included a side trip to Uganda. The patient had taken mefloquine for malaria prophylaxis, but inconsistently. Three months before her return, malaria had reportedly been diagnosed, and she was treated with sulfadoxine-pyrimethamine. Upon admission, she was febrile (101°F) and tachycardic (heart rate: 133 beats/minute). She was noted to be pale and have a palpable spleen but had an otherwise normal physical examination. Admission laboratory tests were notable for anemia (hemoglobin: 10.4 g/dL), hypokalemia (potassium: 2.3 mmol/L), acidosis (bicarbonate: 18 mmol/L), and thrombocytopenia (platelets: 27,000/mm^3). A malaria blood film demonstrated P. *falciparum* (>5% parasitemia). The patient was admitted to the intensive care unit with a diagnosis of malaria and a possible urinary tract infection. She received her first dose of an antimalarial (doxycycline) 9 hours after examination in the emergency department and received her first dose of oral quinine 3 hours later. Intravenous quinidine was eventually initiated >24 hours after admission because it was not available in the hospital pharmacy. A repeat blood film was ordered 48 hours after admission and revealed <1% parasitemia. Two days after admission, the patient had respiratory distress and suffered a cardiac arrest. She was successfully resuscitated, and maintained on mechanical ventilation. She experienced acute respiratory distress syndrome and increasing acidosis. She received multiple blood transfusions and was eventually placed on extracorporeal membrane oxygenation 6 days after admission. The patient then experienced subcutaneous emphysema, and died 7 days after admission. Autopsy findings included severe pulmonary congestion, hepatomegaly and splenomegaly, with malarial pigment visible in both the liver and spleen, and focal cerebral hemorrhage.

Discussion

A total of 1,383 cases of malaria were reported to CDC for 2001, representing a 1.4% decrease from the 1,402 cases reported for 2000. This change primarily resulted from a decrease in cases acquired in Asia and the Americas, which was largely offset by an increase in the number of cases acquired in Africa. Since 2000, CDC has routinely contacted state health departments to ask for outstanding malaria case reports from the previous reporting year or for a statement that reporting is complete. The decrease in cases in 2001, compared with 2000, most likely is as result of expected variation in the number of cases, although other possibilities include decreased international travel, changing patterns of travel (e.g., decreased immigration from malarious areas), or an increased use of effective antimalarial chemoprophylaxis.

One reason for conducting malaria surveillance is to monitor for prophylaxis failures that might indicate emergence of drug resistance; however, ~75% of imported malaria among U.S. civilians occurred among persons who were either not taking prophylaxis or were taking nonrecommended prophylaxis for the region to which they were traveling. Of the 99 cases where appropriate prophylaxis was reported and for whom adequate information was available regarding species and onset of symptoms to indicate that the infection was a primary one rather than a relapse, 66 (i.e., 47 *P. falciparum*, 11 *P. vivax*, 7 *P. malariae*, and 1 *P. ovale*) had insufficient information to determine whether these cases represented problems with adherence while using correct antimalarial chemoprophylaxis, malabsorption of the antimalarial drug, or emerging drug resistance. No conclusive evidence existed to indicate a single national or regional source of infection among this group of patients or the failure of a particular chemoprophylactic regimen. Health-care providers are encouraged to contact CDC rapidly whenever they suspect chemoprophylaxis failure, thus enabling measurement of serum drug levels of the antimalarial drugs in question.

In 2001, to be better able to evaluate chemoprophylaxis failures, CDC revised the NMSS case report form to facilitate collection of more thorough data regarding chemoprophylaxis. The current form solicits more detailed information regarding the prescribed regimen, the degree of compliance with the regimen, and the reasons for noncompliance, if any. Data gathered from the responses will be useful in generating public health messages to improve use of antimalarial chemoprophylaxis and therefore decrease malaria-associated morbidity and mortality among U.S. civilians.

The importance of taking correct precautions and chemoprophylaxis is underscored by the 11 fatal cases of malaria that occurred in the United States in 2001. An earlier review of deaths attributed to malaria in the United States identified certain risk factors for fatal malaria, including failure to take recommended antimalarial chemoprophylaxis, refusal of or delay in seeking medical care, and misdiagnosis (*11*).

The occurrence of 22 cases of malaria among pregnant U.S. civilians is also cause for concern. Malaria during pregnancy among nonimmune women is more likely to result in severe disease or contribute to an adverse outcome than malaria in nonpregnant women (*12*); the fetus might be adversely affected as well (*13*). Pregnant travelers should be counseled to avoid travel to malarious areas, if possible. If deferral of travel is impossible, pregnant women should be informed that the risks for malaria outweigh those associated with

prophylaxis and that safe chemoprophylaxis regimens are available. Specific guidance for pregnant travelers is available from CDC's website at http://www.cdc.gov/travel/mal_preg_pub.htm.

Signs and symptoms of malaria are often nonspecific, but fever is usually present. Other symptoms include headache, chills, increased sweating, back pain, myalgia, diarrhea, nausea, vomiting, and cough. Prompt diagnosis requires that malaria be included in the differential diagnosis of illness in a febrile person with a history of travel to a malarious area. Clinicians should ask all febrile patients for a travel history, including when evaluating febrile illnesses among international visitors, immigrants, refugees, migrant laborers, and international travelers.

Prompt treatment of suspected malaria is essential, because persons with *P. falciparum* infection are at risk for experiencing life-threatening complications. Ideally, therapy for malaria should be initiated immediately after the diagnosis has been confirmed by a positive blood film. Treatment should be determined on the basis of the infecting *Plasmodium* species, the probable geographic origin of the parasite, the parasite density, and the patient's clinical status (*14*). If the diagnosis of malaria is suspected and cannot be confirmed, or if a diagnosis of malaria is confirmed but species determination is not possible, antimalarial treatment should be initiated that is effective against *P. falciparum*. Resistance of *P. falciparum* to chloroquine is worldwide, with the exception of a limited number of geographic regions (e.g., Central America). Therefore, therapy for presumed *P. falciparum* malaria should usually entail the use of a drug effective against such resistant strains.

Health-care workers should be familiar with prevention, recognition, and treatment of malaria and are encouraged to consult appropriate sources (Table 7) for malaria treatment recommendations or call CDC's National Center for Infectious Diseases, Division of Parasitic Diseases, at 770-488-7788. Detailed recommendations for preventing malaria are available 24 hours/day from CDC at telephone 877-394-8747 (toll-free voice information system) or 888-232-3299 (toll-free facsimile request line), or on the Internet at http://www.cdc.gov/travel/diseases.htm/malaria. In addition, CDC biannually publishes recommendations in *Health Information for International Travel* (commonly referred to as *The Yellow Book*) (*9*), which is available for purchase from the Public Health Foundation at 877-252-1200 or 301-645-7773; it is also available and updated more frequently on CDC's Internet site at http://www.cdc.gov/travel.

CDC provides support for the diagnosis of malaria through DPDx, a program that enhances diagnosis of parasitic diseases throughout the world. It includes an Internet site,

TABLE 7. Sources for malaria prophylaxis, diagnosis, and treatment recommendations

Type of information	Source	Availability	Telephone number, Internet address, or electronic mail address
Prophylaxis	CDC's voice information system	24 hours/day	877-394-8747
Prophylaxis	CDC's malaria facsimile	24 hours/day	888-232-3299
Prophylaxis	CDC's traveler's health Internet site	24 hours/day	http://www.cdc.gov/travel
Prophylaxis	*Health Information for International Travel*, *The Yellow Book*	Order from Public Health Publication Sales P.O. Box 753 Waldorf, MD 20604	 877-252-1200 or 301-645-7773 or http://www.phf.org
Prophylaxis	*Health Information for International Travel*	24 hours/day	http://www.cdc.gov/travel
Diagnosis	CDC's Division of Parasitic Diseases Diagnostic Internet site (DPDx)	24 hours/day	http://www.dpd.cdc.gov/dpdx
Diagnosis	CDC's Division of Parasitic Diseases diagnostic CD-ROM (DPDx)	Order by electronic mail from CDC Division of Parasitic Diseases	dpdx@cdc.gov
Treatment*	CDC's Malaria EpidemiologyBranch	8:00 am–4:30 pm Eastern Time, Monday–Friday	770-488-7788*
Treatment (after routine business hours)*	CDC's Malaria Epidemiology Branch	4:30 pm–8:00 am Eastern Time, weekends and holidays	404-639-2888* (Ask operator to page clinical officer on call for Malaria Branch)

* These telephone numbers are intended for use by health-care professionals only.

http://www.dpd.cdc.gov/dpdx, that contains information regarding laboratory diagnosis, geographic distribution, clinical features, treatment, and life cycles of >100 parasite species. The DPDx Internet site is also a portal for diagnostic assistance for health-care providers through telediagnosis. Digital images captured from diagnostic specimens are submitted for diagnostic consultation through electronic mail. Because laboratories can transmit images to CDC and rapidly obtain answers to their inquiries, this system allows more efficient diagnosis of difficult cases and more rapid dissemination of information. Approximately 41 public health laboratories in 38 states and Puerto Rico have, or are in the process of acquiring, the hardware to perform telediagnosis.

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References

1. World Health Organization. World malaria situation in 1994. Wkly Epidemiol Rec 1997;72:269–76.
2. Bremen JG. The ears of the hippopotamus: manifestations, determinants, and estimates of the malaria burden. Am J Trop Med Hyg 2001;64(suppl 1):1–11.
3. Pan American Health Organization. Report for registration of malaria eradication from United States of America. Washington, DC: Pan American Health Organization, 1969.
4. Zucker JR. Changing patterns of autochthonous malaria transmission in the United States: a review of recent outbreaks. Emerg Infect Dis 1996;2:37–43.
5. Lackritz EM, Lobel HO, Howell J, Bloland P, Campbell CC. Imported *Plasmodium falciparum* malaria in American travelers to Africa: implications for prevention strategies. JAMA 1991;265:383–5.
6. Stroup DF. Special analytic issues. In: Teutsch SM, Churchill RE, eds. Principles and practice of public health surveillance. New York, NY: Oxford University Press, 1994;143–5.
7. World Health Organization. Terminology of malaria and of malaria eradication: report of a drafting committee. Geneva, Switzerland: World Health Organization, 1963;32.
8. Causer LM, Newman RD, Barber AM, et al. Malaria surveillance—United States, 2000. In: CDC Surveillance Summaries (July 12, 2002). MMWR 2002;51(No. SS-5):9–23.
9. CDC. Health information for international travel, 2001–2002. Atlanta, GA: US Department of Health and Human Services, Public Health Service, CDC, National Center for Infectious Diseases, 2001.
10. CDC. Malaria deaths following inappropriate malaria chemoprophylaxis—United States, 2001. MMWR 2001:50;597–9.
11. Greenberg AE, Lobel HO. Mortality from *Plasmodium falciparum* malaria in travelers from the United States, 1959 to 1987. Ann Intern Med 1990;113:326–7.
12. Luxemburger C, Ricci F, Nosten F, Raimond D, Bathet S, White NJ. The epidemiology of severe malaria in an area of low transmission in Thailand. Trans R Soc Trop Med Hyg 1997;91:256–62.
13. Nosten F, Kuile F, Maelankirri L, Decludt B, White NJ. Malaria during pregnancy in an area of unstable endemicity. Trans R Soc Trop Med Hyg 1991;85:424–9.
14. Zucker JR, Campbell CC. Malaria: principles of prevention and treatment. Infect Dis Clin North Am 1993;7:547–67.

Appendix

Microscopic Procedures for Diagnosing Malaria

To establish the diagnosis of malaria, a blood film must be prepared from fresh blood obtained by pricking the patient's finger (Figures A-1 and A-2).* The thin film is fixed in methanol before staining; the thick film is stained unfixed. Certain hospitals have a Wright-Giemsa stain available, which is acceptable; however, Wright stain alone will not reliably indicate *Plasmodium* parasites. For best results, the film should be stained with a 3% Giemsa solution (pH of 7.2) for 30–45 minutes. In *P. falciparum* infections, the parasite density should be estimated by counting the percentage of red blood cells infected — not the number of parasites — under an oil immersion lens on a thin film.

Thick blood films are more sensitive in detecting malaria parasites because the blood is concentrated, allowing a greater volume of blood to be examined. However, thick films are more difficult to read, and thin films might be preferred by laboratories that have limited experience. *Plasmodium* parasites are always intracellular, and they demonstrate, if stained correctly, blue cytoplasm with a red chromatin dot. Common errors in reading malaria films are caused by platelets overlying a red blood cell, concern regarding missing a positive slide, and misreading artifacts as parasites. Persons suspected of having malaria, but whose blood films do not indicate the presence of parasites, should have blood films repeated approximately every 12–24 hours for 3 consecutive days. If films remain negative, then the diagnosis of malaria is unlikely.

For rapid diagnosis, the thick and thin films should be made on separate slides. The thin film should be air-dried, fixed with methyl alcohol, and immediately stained. If no parasites are visible on the thin film, the laboratorian should wait until the thick film is dry, then examine it for organisms that might not have been detected on the thin preparation.

* In Figures A-1 and A-2, the hands are illustrated ungloved to better indicate their placement during the procedures. However, wearing gloves while processing blood specimens is recommended to prevent transmission of bloodborne pathogens (*MMWR 1988;37:377–82, 387–8* and *MMWR 1987;36[No. S2]*).

FIGURE A-1. Blood collection for thin or thick blood films

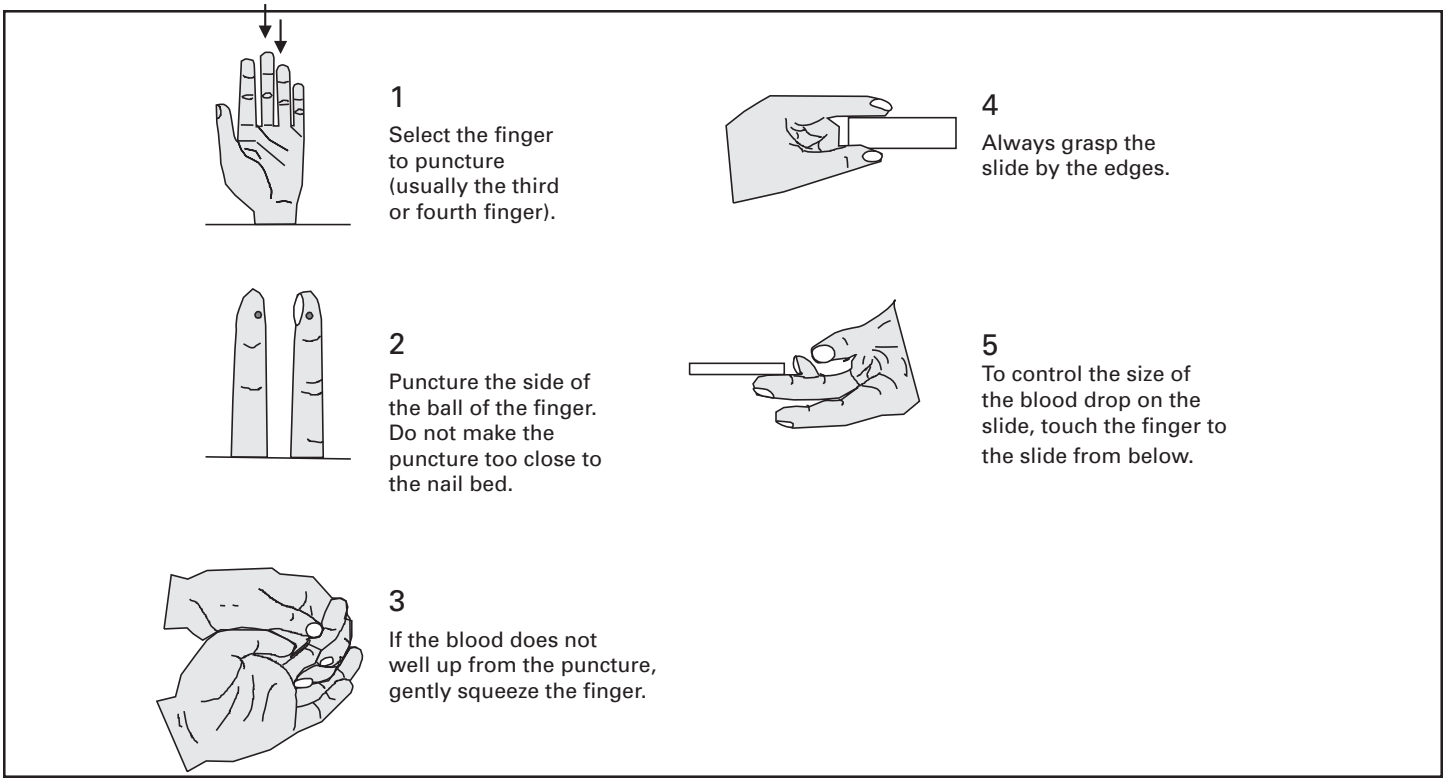
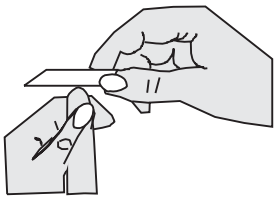
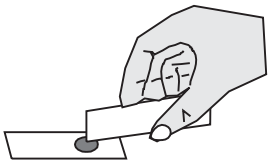


FIGURE A-2. Preparation of a thin and a thick blood film on the same slide



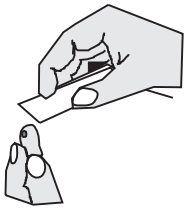
1

Touch the blood drop with a clean slide.



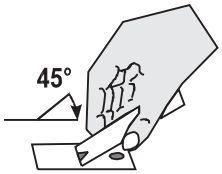
2

Using the corner of another slide, spread the blood drop into the shape of a circle or square of ~1cm^2.



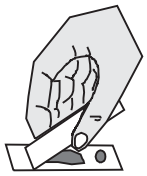
3

Gently squeeze the patient's finger again, and touch the edge of a clean slide to the newly formed blood drop.



4

Take this slide and hold the edge that has the blood drop at an ~45° angle against the surface of the first slide. Wait until the blood completely spreads along the edge of the second slide.



5

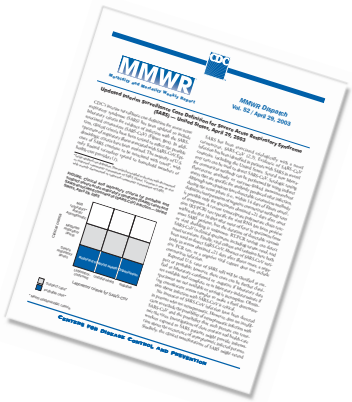
While holding the second slide at the same angle, rapidly and smoothly push the slide forward.

6

Write the identification number on the slide. Wait until the thick film is completely dry before staining it.

up-to-the-minute: *adj*

1 : extending up to the immediate present, including the very latest information; see also *MMWR*.



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