CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

December 7, 2001 / Vol. 50 / No. SS-5

MMWR™
MORBIDITY AND MORTALITY
WEEKLY REPORT

CDC Surveillance Summaries

Malaria Surveillance — United States, 1998

U.S. DEPARTMENT OF HEALTH & HUMAN SERVICES
Centers for Disease Control and Prevention (CDC)
Atlanta, GA 30333

The *MMWR* series of publications is published by the Epidemiology Program Office, Centers for Disease Control and Prevention (CDC), U.S. Department of Health and Human Services, Atlanta, GA 30333.

SUGGESTED CITATION

General: Centers for Disease Control and Prevention. *CDC Surveillance Summaries*, December 7, 2001. MMWR 2001;50(No. SS-5).

Specific: [Author(s)]. [Title of particular article.] In: *CDC Surveillance Summaries*, December 7, 2001. MMWR 2001;50(No. SS-5):[inclusive page numbers].

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*Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
CIO	Centers/Institute/Offices
EPO	Epidemiology Program Office
IHPO	International Health Program Office
NCCDPHP	National Center for Chronic Disease Prevention and Health Promotion
NCEH	National Center for Environmental Health
NCEHIC	National Center for Environmental Health and Injury Control
NCHSTP	National Center for HIV, STD, and TB Prevention
NCID	National Center for Infectious Diseases
NCIPC	National Center for Injury Prevention and Control
NCPS	National Center for Prevention Services
NIOSH	National Institute for Occupational Safety and Health
NIP	National Immunization Program

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Malaria Surveillance — United States, 1998

Timothy H. Holtz, M.D., M.P.H.[1,2]
S. Patrick Kachur, M.D., M.P.H.[2]
John R. MacArthur, M.D., M.P.H.[1,2]
Jacquelin M. Roberts, M.S.[2]
Ann M. Barber[2]
Richard W. Steketee, M.D., M.P.H.[2]
Monica E. Parise M.D.[2]
[1]Epidemic Intelligence Service, Epidemiology Program Office
[2]Division of Parasitic Diseases, National Center for Infectious Diseases

Abstract

Problem/Condition: Human malaria is caused by one or more of four species of intraerythrocytic protozoa of the genus *Plasmodium* (i.e., *P. falciparum*, *P. vivax*, *P. ovale*, or *P. malariae*). The protozoa are transmitted by the bite of an infective female *Anopheles* species mosquito. The majority of malaria infections in the United States occur among persons who have traveled to areas with endemic transmission. Cases occasionally occur that are acquired 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.

Reporting Period: Cases with an onset of symptoms during 1998.

Description of System: Malaria cases confirmed by blood smear are reported to local and state health departments by health-care providers and laboratory staff members. Case investigations are conducted by local and state health departments, and reports are sent to CDC through the National Malaria Surveillance System (NMSS). This report uses NMSS data.

Results: CDC received reports of 1,227 cases of malaria with onsets of symptoms in 1998, among persons in the United States and its territories. This number represents a decrease of 20.5% from the 1,544 cases reported during 1997. *P. falciparum*, *P. vivax*, *P. malariae*, and *P. ovale* were identified in 42.8%, 37.8%, 3.5%, and 2.1% of cases, respectively. More than one species was present in seven patients (0.6% of total). The infecting species was not determined in 162 (13.2%) cases.

Compared with reported cases in 1997, reported malaria cases acquired in Africa increased by 1.3% (n = 706); those acquired in Asia decreased by 52.1% (n = 239); and those acquired in the Americas decreased by 6.5% (n = 229). Of 636 U.S. civilians who acquired malaria abroad, 126 (19.8%) reportedly had followed a chemoprophylactic drug regimen recommended by CDC for the area to which they had traveled.

Five persons became infected in the United States. One case was congenitally acquired; one was acquired by blood transfusion; and three were isolated cases that could not be epidemiologically linked to another case. Four deaths were attributed to malaria.

Interpretation: The 20.5% decrease in malaria cases during 1998 compared with 1997 resulted primarily from decreases in *P. vivax* cases acquired in Asia among non-U.S.

civilians. This decrease could have resulted from local changes in disease transmission, decreased immigration from the region, decreased travel to the region, incomplete reporting from state and local health departments, or increased use of effective antimalarial chemoprophylaxis. In a majority of reported cases, U.S. civilians who acquired infection abroad had not taken an appropriate chemoprophylaxis regimen for the country where they acquired malaria.

Public Health Actions Taken: Additional information was obtained from state and local health departments and clinics concerning the four fatal cases and the five infections acquired in the United States. Persons traveling to a malarious area should take a recommended chemoprophylaxis regimen and use personal protection measures to prevent mosquito bites. Any person who has been to a malarious area and subsequently develops fever or influenza-like symptoms should seek medical care immediately; the investigation should include a blood smear for malaria. Malaria infections can be fatal if not diagnosed and treated promptly. Current recommendations concerning prevention and treatment of malaria can be obtained from CDC.

INTRODUCTION

Human malaria is caused by infection with one or more of four species of *Plasmodium* parasites (i.e., *P. falciparum*, *P. vivax*, *P. ovale*, and *P. malariae*). The infection is transmitted by the bite of an infective female *Anopheles* species mosquito. Malaria remains a global problem, with an estimated 300–500 million cases occurring annually. A total of 41% of the world's population lives in areas where malaria is transmitted regularly (e.g., parts of Africa, Asia, the Middle East, Central and South America, Hispaniola, and Oceania), and approximately 1.5–2.7 million persons die of malaria each year (*1*).

Malaria was also endemic throughout a majority of the continental United States during the 1900s. Approximately 600,000 cases occurred in 1914 (*2*). During the late 1940s, a combination of improved socioeconomic conditions, water management, vector-control efforts, and case management was successful in interrupting malaria transmission in the United States. Subsequently, malaria case surveillance has been maintained to detect locally acquired cases that could indicate the reintroduction of transmission, and to monitor patterns in antimalarial drug resistance that guide prevention recommendations for U.S. travelers.

The majority of malaria cases diagnosed in the United States are imported from regions of the world where malaria transmission is known to occur. However, each year congenital infections and infections resulting from exposure to blood or blood products are reported in the United States. Cases also are reported that might have been acquired through local mosquitoborne transmission (*3,4*).

State and local health departments and CDC investigate all malaria cases acquired in the United States, and CDC analyzes all imported cases to detect trends in acquisition. 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 for Africa in 1990 (*5*).

The signs and symptoms of malaria are variable, but a majority of patients have fever. Other common symptoms include headache, back pain, chills, increased sweating, myalgia, nausea, vomiting, diarrhea, and cough. Malaria should be considered

when any of these symptoms occurs in a person who has traveled to an area endemic for malaria transmission. Malaria also should be considered in the differential diagnosis for persons with fever of unknown origin, regardless of their travel history. Untreated *P. falciparum* infection can rapidly progress to coma, renal failure, pulmonary edema, and death. Asymptomatic parasitemia can occur among persons who have been long-term residents of malarious areas. This report summarizes malaria cases reported to CDC that had onsets of symptoms during 1998.

METHODS

Sources of Data

Data regarding malaria cases 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, reported case numbers might differ because of differences in data collection and transmission. 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 in which the infected person traveled). Cases of blood-smear–confirmed malaria are identified by health-care providers and laboratories. Each slide-confirmed case is reported to local and state health departments and to CDC on a uniform case report form that contains clinical, laboratory, and epidemiologic information. CDC staff members review all report forms at the time of receipt and request additional information if necessary (e.g., when no recent travel to a malarious country is reported). Reports of other cases are telephoned directly to CDC by health-care providers, usually when assistance with diagnosis or treatment is requested. All cases 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 on blood films.
- ***Confirmed case:*** Symptomatic or asymptomatic infection that occurs in the United States in a person who has microscopically 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 differ 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, possibly resulting from drug resistance, if the demonstrated *Plasmodium* species is the same species identified previously, and is not counted as an additional case.

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

- **Autochthonous malaria:**
  - — **Indigenous.** Mosquitoborne transmission of malaria in an 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 (including Puerto Rico, Guam, and the U.S. Virgin Islands).
- **Induced malaria:** Malaria acquired through hematogenous means (e.g., blood transfusion or use of shared syringes).
- **Relapsing malaria:** Renewed manifestations (i.e., clinical symptoms and parasitemia) from a previous malaria infection reoccurring at a longer interval than is typical of the infection.
- **Cryptic malaria:** An isolated malaria case that cannot be linked epidemiologically to secondary cases.

Microscopic Diagnosis of Malaria

Early diagnosis of malaria requires that physicians consider malaria for every patient who has fever; evaluation of such a patient should include a comprehensive travel history. If malaria is suspected, a Giemsa-stained smear of the patient's peripheral blood should be examined for parasites. Thick and thin blood smears must be prepared properly because the accuracy of diagnosis depends on the quality of the blood smear and the experience of the laboratory personnel*(Appendix A).

RESULTS

General Surveillance

CDC received reports of 1,227 malaria cases with onset of symptoms in 1998, among persons in the United States and its territories, representing a 20.5% decrease from the 1,544 cases reported for 1997 (*8*). This incidence is the fourth highest annual number of reported cases since 1980 and the second highest number of U.S. civilian cases reported in each year since 1968 (Table 1). In 1998, a total of 636 cases occurred among U.S. civilians, compared with 698 cases reported for 1997, whereas the number of cases among non-U.S. civilians decreased from 592 cases to 361 (Figure 1). Cases among U.S. military personnel also decreased from 28 to 22 in 1998. In 208 cases, available information was insufficient to determine whether the person was civilian or military personnel.

*To obtain confirmation diagnosis of blood smears 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 (Box).

TABLE 1. Number of malaria cases* in U.S. and non-U.S. civilians and U.S. military personnel — United States, 1969–1998

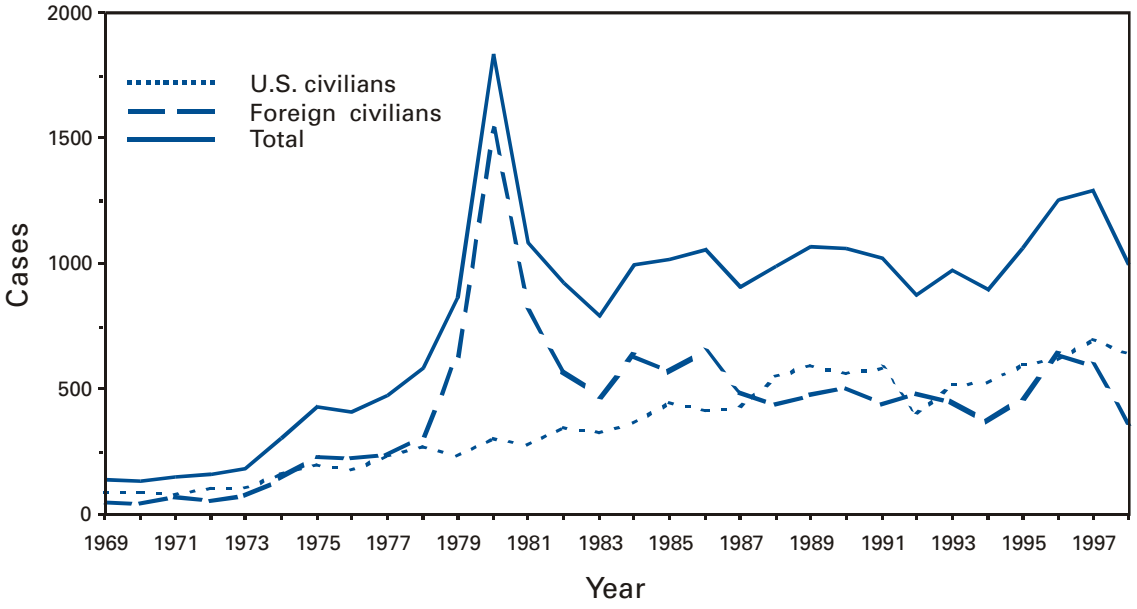
Year	U.S. military personnel	U.S. civilians	Non-U.S. civilians	Unknown	Total
1969	3,914	90	47	11	4,062
1970	4,096	90	44	17	4,247
1971	2,975	79	69	57	3,180
1972	454	106	54	0	614
1973	41	103	78	0	222
1974	21	158	144	0	323
1975	17	199	232	0	448
1976	5	178	227	5	415
1977	11	233	237	0	481
1978	31	270	315	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

*A case was defined as symptomatic or asymptomatic illness that occurs in the United States in a person who has malaria parasitemia confirmed by microscopy, 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.

Plasmodium Species

The infecting species of *Plasmodium* was identified in 1,065 (86.8%) cases reported in 1998. *P. falciparum* and *P. vivax* were identified in blood smears from 42.8% and 37.8% of infected persons, respectively (Table 2). The 464 *P. vivax* cases reported for 1998 represented a 38.5% decrease from the 755 cases reported in 1997. The number of *P. falciparum* infections also decreased, but only by 7.4% (from 567 in 1997 to 525 in 1998). Among 1,202 cases in which both the region of acquisition and the infecting species were known, 62.6% of infections acquired in Africa were attributed to

FIGURE 1. Number of malaria cases in U.S. and foreign civilians — United States,* 1969–1998†



* 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 in immigrants from Southeast Asia after the Vietnam conflict.

TABLE 2. Number of malaria cases, by *Plasmodium* species — United States, 1997 and 1998

Plasmodium species	1997 No.	1997 (%)	1998 No.	1998 (%)
P. falciparum	567	(36.7)	525	(42.8)
P. vivax	755	(48.9)	464	(37.8)
P. malariae	48	(3.1)	43	(3.5)
P. ovale	31	(2.0)	26	(2.1)
Undetermined	134	(8.7)	162	(13.2)
Mixed	9	(0.6)	7	(0.6)
Total	**1,544**	**(100.0)**	**1,227**	**(100.0)**

P. falciparum, and 14.2% were attributed to *P. vivax*. For infections acquired in Asia and the Americas, 78.2% and 67.7%, respectively, were attributed to *P. vivax,* and only 9.2% and 20.5% respectively, were attributed to *P. falciparum.* A 56.7% decrease occurred (432 cases in 1997 to 187 cases in 1998) in *P. vivax* cases acquired in Asia, a majority of which were acquired in India (371 cases in 1997 and 123 cases in 1998).

Imported Malaria Cases

Region of Acquisition and Diagnosis

Of all reported cases, 98% (n = 1,206) were classified as imported. Of 1,197 imported cases in which the region of acquisition was known, 60% (n = 706) were acquired in Africa, 20% (n = 239) in Asia, and 19.1% (n = 229) in the Americas (Table 3). The highest

TABLE 3. Malaria cases, by *Plasmodium* species and by country of acquisition — United States, 1998

Country of acquisition	*Plasmodium* species						
	P. vivax	*P.falciparum*	*P.malariae*	*P.ovale*	Unknown	Mixed	Total
Africa	**100**	**442**	**27**	**22**	**113**	**2**	**706**
Algeria	0	1	0	0	0	0	1
Angola	1	3	0	0	1	0	5
Benin	0	1	0	0	0	0	1
Botswana	0	0	0	0	2	0	2
Burkina Faso	0	3	0	0	1	0	4
Burundi	0	0	0	0	3	0	3
Cameroon	3	12	0	2	3	0	20
Central African Republic	0	1	0	0	0	0	1
Congo	0	6	0	1	1	0	8
Cote D'Ivoire	1	17	2	1	5	0	26
Democratic Republic of the Congo (Zaire)	0	4	0	1	0	0	5
Equitorial Guinea	0	1	0	0	0	0	1
Eritrea	0	1	0	0	0	0	1
Ethiopia	14	2	0	0	2	0	18
Gabon	0	1	0	0	1	0	2
Gambia	0	8	0	0	1	0	9
Ghana	5	90	3	3	16	0	117
Guinea	1	14	0	1	0	0	16
Kenya	18	30	2	1	4	0	55
Liberia	4	38	3	0	19	0	64
Libya	0	0	1	0	0	0	1
Madagascar	9	0	0	1	1	0	11
Malawi	0	3	0	0	1	1	5
Mali	2	5	0	0	1	0	8
Mauritania	1	0	0	0	0	0	1
Morocco	1	0	0	0	0	0	1
Mozambique	1	1	0	0	0	0	2
Niger	2	2	0	0	0	0	4
Nigeria	10	125	8	6	26	1	176
Rwanda	0	0	1	0	1	0	2
Senegal	0	11	1	0	3	0	15
Sierra Leone	2	0	0	0	0	0	2
Somali Republic	3	0	0	1	1	0	5
South Africa	1	5	0	0	2	0	8
Sudan	4	9	0	0	1	0	14
Tanzania	6	8	0	2	3	0	19
Togo	0	0	0	1	2	0	3
Uganda	3	9	1	0	3	0	16
Zambia	1	2	1	0	1	0	5
Zimbabwe	1	4	2	0	2	0	9
East Africa, Unspecified	1	0	0	0	1	0	2
West Africa, Unspecified	4	6	1	1	1	0	13
Africa, Unspecified	3	17	1	0	4	0	25
Asia	**187**	**22**	**5**	**1**	**22**	**2**	**239**
Afghanistan	1	0	0	0	0	0	1
Burma	3	0	0	1	1	0	5
India	123	9	5	0	10	1	148
Indonesia	13	4	0	0	5	1	23
Rep. of Korea	14	0	0	0	1	0	15
Laos	5	0	0	0	0	0	5
Nepal	0	1	0	0	0	0	1

TABLE 3. (*Continued*) Malaria cases, by *Plasmodium* species and by country of acquisition — United States, 1998

Country of acquisition	*Plasmodium* species						Total
	P. vivax	*P.falciparum*	*P.malariae*	*P.ovale*	Unknown	Mixed	
Pakistan	14	1	0	0	1	0	16
Philippines	5	2	0	0	1	0	8
Saudi Arabia	0	1	0	0	0	0	1
Sri Lanka	1	0	0	0	1	0	2
Thailand	3	2	0	0	0	0	5
Vietnam	1	0	0	0	2	0	3
Yemen	2	2	0	0	0	0	4
Asia, Unspecified	1	0	0	0	0	0	1
Southeast Asia, Unspecified	1	0	0	0	0	0	1
Central America and Caribbean	**110**	**40**	**6**	**2**	**10**	**2**	**170**
Dominican Republic	0	3	0	0	0	0	3
Costa Rica	3	0	1	0	0	0	4
El Salvador	16	5	0	0	1	1	23
Guatemala	20	2	2	0	4	0	28
Haiti	0	25	0	0	0	0	25
Honduras	55	3	2	2	4	1	67
Nicaragua	12	2	1	0	1	0	16
Panama	1	0	0	0	0	0	1
Central America, Unspecified	3	0	0	0	0	0	3
North America	**15**	**2**	**2**	**0**	**3**	**1**	**23**
United States	2	2	0	0	1	0	5
Mexico	13	0	2	0	2	1	18
South America	**32**	**7**	**2**	**0**	**0**	**0**	**41**
Bolivia	1	0	0	0	0	0	1
Brazil	3	0	0	0	0	0	3
Colombia	5	1	0	0	0	0	6
Ecuador	6	2	1	0	0	0	9
Guyana	14	3	1	0	0	0	18
Peru	1	0	0	0	0	0	1
South America, Unspecified	2	1	0	0	0	0	3
Oceania	**10**	**5**	**1**	**1**	**6**	**0**	**23**
Papua New Guinea	9	5	1	1	6	0	22
Vanuatu	1	0	0	0	0	0	1
Unknown	**10**	**7**	**1**	**0**	**8**	**0**	**25**
Total	**464**	**525**	**43**	**26**	**162**	**7**	**1,227**

proportion of cases acquired in Africa , 65.2% (n = 460), came from countries in West Africa. The majority of cases acquired in Asia came from the Indian subcontinent 61.9% (n = 148). The other regions where imported cases of malaria were acquired were Central America and the Caribbean 14.2% (n = 170); South America 3.4% (n = 41); Oceania 1.9% (n = 23); and Mexico 1.5% (n = 18). Reported malaria cases acquired in Africa increased by 1.3% (n = 706) compared with 1997, and cases acquired in Asia decreased by 52.1% (n = 239) compared with 1997. Cases from the Americas decreased by 6.5% (n = 229) compared with 1997.

In the United States, the seven areas reporting the highest number of malaria cases were California (n = 232), New York City (n = 228), Minnesota (n = 83), New York State (n = 75), Illinois (n = 62), Virginia (n = 54), and Florida (n = 47) (Figure 2). When compared with 1997, each of these areas reported fewer cases in 1998, except for Minnesota, which reported an increase to 83 from 60 cases in 1997. The overall decrease in reported number of cases might be a result of decreased international travel or immigration, improved use of chemoprophylaxis, or less sensitive surveillance.

Interval Between Arrival and Onset of Symptoms

The interval between persons arriving in the United States and onset of symptoms as well as the infecting *Plasmodium* species was known for 609 (50.5%) of the imported cases of malaria (Table 4). Symptoms began after arrival in the United States for 552 (90.6%) of these persons. Clinical malaria developed in persons within 1 month after their arrival in 261 (78.4%) of the 333 *P. falciparum* cases and in 87 (35.8%) of the 243 *P. vivax* cases (Table 4). Only 11 (1.8%) persons reported the onset of symptoms >1 year after returning to the United States. A total of 57 (9.4%) persons reported the onset of symptoms before arriving in the United States.

Imported Malaria Among U.S. and Non-U.S. Civilians

During 1998, a total of 997 imported malaria cases was reported among civilians. Of these, 636 (63.8%) occurred among U.S. residents, and 361 (36.2%) occurred among residents of other countries (Table 5). Of the 636 imported malaria cases among U.S. civilians, 394 (62.0%) were acquired in Africa, an increase of 11.6% from the cases

FIGURE 2. Number of malaria cases, by state in which the disease was diagnosed — United States, 1998

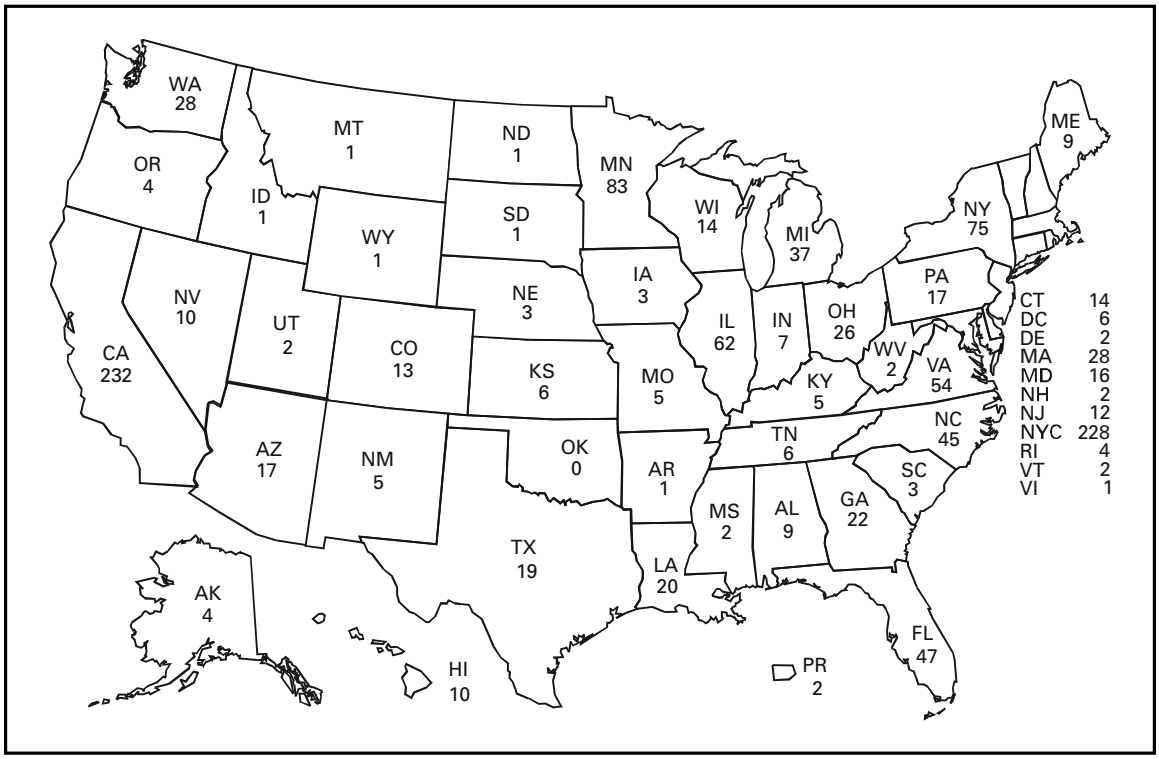


TABLE 4. Number of imported malaria cases, by *Plasmodium* species and by interval between date of arrival in the country and onset of illness — United States, 1998

Interval	*P. vivax*		*P. falciparum*		*P. malariae*		*P. ovale*		Mixed		Total	
(days)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)
<0*	16	(6.6)	40	(2.0)	0	(0.0)	0	(0.0)	1	(25.0)	**57**	**(9.4)**
0-29	87	(35.8)	261	(78.4)	14	(77.7)	2	(18.2)	2	(50.0)	**366**	**(60.1)**
30-89	32	(13.2)	25	(7.5)	2	(11.1)	5	(45.4)	1	(25.0)	**65**	**(10.7)**
90-179	43	(17.7)	0	(0)	1	(5.6)	3	(27.3)	0	(0.0)	**47**	**(7.7)**
180-364	56	(23.0)	6	(1.8)	0	(0.0)	1	(9.1)	0	(0.0)	**63**	**(10.3)**
≥365	9	(3.7)	1	(0.3)	1	(5.6)	0	(0.0)	0	(0.0)	**11**	**(1.8)**
Total	**243**	**(100.0)**	**333**	**(100.0)**	**18**	**(100.0)**	**11**	**(100.0)**	**4**	**(100.0)**	**609**	**(100.0)**

* Persons in these cases had onset of illness before arriving in the United States.

TABLE 5. Number of imported malaria cases in U.S. and non-U.S. civilians, by region of acquisition — United States, 1998**

Area or region of acquisition	U. S. civilians		Non-U.S. civilians		Total	
	No.	(%)	No.	(%)	No.	(%)
Africa	394	(62.0)	185	(51.3)	**579**	**(58.1)**
Asia	112	(17.6)	86	(23.8)	**198**	**(19.9)**
Central America/ Caribbean	77	(12.1)	67	(18.5)	**144**	**(14.4)**
North America	9	(1.4)	8	(2.2)	**17**	**(1.7)**
Oceania	16	(2.5)	4	(1.1)	**20**	**(2.0)**
South America	26	(4.1)	10	(2.8)	**36**	**(3.6)**
Unknown	2	(0.3)	1	(0.3)	**3**	**(0.3)**
Total	**636**	**(100.0)**	**361**	**(100.0)**	**997**	**(100.0)**

reported in 1997. An additional 112 (17.6%) cases were acquired in Asia. The Central American and Caribbean region was the reported source of 77 (12.1%) cases of imported malaria among U.S. civilians.

Among 361 imported cases among non-U.S. civilians, 51.2% (n = 185) were acquired in Africa; 23.8% (n = 86), Asia; and 18.6% (n = 67), Central America and the Caribbean. The number of cases among non-U.S. civilians acquired in Asia (particularly in India) decreased 70.8%, from 295 cases in 1997 to 86 cases in 1998.

Imported Malaria Among Military Personnel

A total of 22 cases of imported malaria among U.S. military personnel were reported for 1998. This represents a 21% decrease from 28 cases reported among U.S. military personnel in 1997.

Use of Antimalarial Chemoprophylaxis

Use of Chemoprophylaxis Among U.S. Civilians

Information concerning the use of chemoprophylaxis and area of travel was known for 584 (91.8%) of the 636 U.S. civilians who had imported malaria. Of these 584 persons,

347 (59.4%) had not taken any chemoprophylaxis, and 78 (13.4%) had not taken the CDC-recommended drug for the area(s) visited. Only 126 (21.6%) U.S. civilians had taken a medication recommended by CDC (*9*). For the remaining 33 (5.6%) travelers, data regarding the drug taken were missing. A total of 104 of the 126 U.S. civilian patients who took CDC-recommended chemoprophylaxis had taken mefloquine weekly; nine had taken doxycycline daily; and 13, who had traveled only in areas where chloroquine-resistant malaria has not been documented, had taken chloroquine weekly. Of the 78 patients taking a non-recommended drug, information regarding the type of chemoprophylaxis used was known for 75. Of these 75 persons, 64 (85.3%) reported taking chloroquine and proguanil during travel to an area where chloroquine resistance had been documented.

Use of Chemoprophylaxis Among Military Personnel

Of the 19 military personnel for whom information regarding chemoprophylaxis use was available, 11 (57.9%) were not using any chemoprophylaxis. In 1997, by comparison, 10 of 26 (38.4%) military case-patients for whom information on chemoprophylaxis was available, had not used any chemoprophylaxis.

Malaria Infection After Using Recommended Chemoprophylaxis

A total of 155 (126 U.S. civilians, seven persons in the U.S. military, five non-U.S. civilians, and 17 persons with missing information) acquired malaria after taking recommended antimalarial chemoprophylaxis. The infecting species could not be determined for 24 (15.5%) patients.

Of the 155 patients who acquired malaria after using recommended chemoprophylaxis, 87 cases (53.5%) were caused by *P. vivax* (n = 83) or *P. ovale* (n = 4). The remaining 44 cases of malaria reported among persons who had taken a recommended antimalarial chemoprophylaxis included 39 cases of *P. falciparum*, 4 of *P. malariae,* 1 of mixed infection (*P. falciparum* and *P. vivax*), and 24 in which the infecting species was not identified.

P. vivax or P. ovale Cases

Malaria case surveillance reports indicated that 15 (17.2%) of 87 patients with *P. vivax* or *P. ovale* did not complete their antimalarial chemoprophylaxis as recommended. A total of 54 (50.6%) cases of *P. vivax or P. ovale* occurred >45 days after persons arrived in the United States. These cases were consistent with relapsing infections and, thus, do not necessarily indicate chemoprophylaxis failures. Because of insufficient information regarding 34 cases, no determination could be made regarding whether these persons had relapsing infections. Nine cases of *P. vivax* occurred $\leq$45 days after the person returned to the United States. Of these persons, two did not complete their antimalarial chemoprophylaxis as recommended. The region of acquisition varied for the seven persons who had completed chemoprophylaxis as recommended (i.e., one from Central America, four from South America, two from southeast Asia). No blood specimens were available to check serum drug levels for any of these persons. These apparent chemoprophylaxis failures might have been caused by inadequate dosing or unreported failure to complete the recommended chemoprophylaxis regimen. These data are insufficient to indicate new areas of chloroquine-resistant *P. vivax*.

P. falciparum Cases

Among 39 cases of *P. falciparum* where persons reported taking recommended antimalarial chemoprophylaxis, 36 acquired infection in Africa, one in Papua New Guinea, and two in Central America and the Caribbean. Twelve (30.8%) of these persons reported not completing their chemoprophylaxis as recommended. Two of these 12 persons had high density parasitemia and required exchange blood transfusion. A total of 27 (69.2%) persons acquired *P. falciparum* infections despite reportedly taking the recommended chemoprophylaxis regimen as directed. However, serum drug levels were unavailable for these persons. These failures might have been caused by inappropriate dosing or failure to complete the recommended regimen.

Purpose of Travel

The purpose of travel to malarious areas was reported for 495 (77.8%) of the 636 U.S. civilians with imported malaria (Table 6). Of cases among U.S. civilians, the largest percentage (38.5%) occurred among persons who were visiting friends or relatives in malarious areas; 11.6% and 10.1% of persons had traveled for tourism and business purposes, respectively.

Malaria Acquired in the United States

Congenital Malaria

Case 1. On August 19, 1998, a full-term infant was born by spontaneous vaginal delivery in Arizona. His parents were Ethiopian immigrants. During September–November 1997, they had returned to Ethiopia. In January 1998, *P. vivax* was diagnosed in the infant's mother and she was treated with chloroquine but was not administered primaquine because she was pregnant. In May 1998, she experienced a relapse of *P. vivax* and was retreated with chloroquine, and then administered chloroquine weekly for chemoprophylaxis until delivery. The woman discontinued chloroquine 4 weeks before delivery because of concerns regarding the drug's potential adverse effects on the fetus. At the time of delivery, she experienced high fevers and rigors. Repeat blood smears indicated *P. vivax*, and after delivery she was treated with chloroquine and primaquine. A blood smear was not performed on the newborn, and he was not treated at the time of delivery.

TABLE 6. Number of imported malaria cases in U.S. civilians, by purpose of travel at the time of acquisition — United States, 1998

	Imported cases	
Purpose	**No.**	**(%)**
Visiting friends/relatives	245	(38.5)
Other	141	(22.2)
Tourism	74	(11.6)
Business representative	64	(10.1)
Missionary or dependent	46	(7.2)
Student/Teacher	46	(7.2)
Peace Corps volunteer	8	(1.3)
Air crew/Sailor	5	(0.8)
Total	**636**	**(100.0)**

On September 7, the 18-day-old infant was hospitalized with a 1-day history of fever and refusal to feed. His physical examination and laboratory tests were normal. However, a blood smear revealed *P. vivax* with 3% parasitemia and mature gametocytes. The infant was treated with chloroquine and the density of his parasitemia decreased to 1% after 1 day. He improved clinically and was discharged September 9.

Cryptic Malaria

Case 1. On July 17, 1998, a woman aged 63 years, from Virginia, reported fever, myalgia, stiff neck, and diarrhea. Her family noted that she appeared less coherent than usual. She experienced high fever and somnolence and was admitted to the hospital on July 19. At the time of admission to a hospital, laboratory tests were normal except for thrombocytopenia. On July 20, *P. falciparum* was identified by a blood smear examination. She responded well to 7 days of quinine and doxycycline. The patient was born in the United States and had no history of international travel. She reported no history of previous malaria infection, transfusion of blood or blood products, organ transplantation, or injection-drug use.

The state health department and CDC conducted epidemiologic and environmental investigations to identify additional cases of locally acquired malaria. Active case finding was conducted in surrounding counties, including a serologic study of 88 migrant farm workers living and working near the patient's residence. No additional cases of malaria were reported. An environmental investigation using larval collections, light traps, and landing collections identified *A. quadrimaculatus* group, *A. crucians sensu strictu*, and *A. punctipennis* (*10*). All are competent malaria vectors. The source of infection was not determined.

Case 2. On October 3, 1998, a man aged 19 years was admitted to a hospital in New Jersey after 10 days of nausea, vomiting, headaches, myalgia, cyclic fevers, and jaundice. *P. vivax* parasites were identified on a routine complete blood count. He was treated with chloroquine, and responded rapidly. Upon discharge, a 14-day course of primaquine was administered. The patient reported no history of receiving a blood transfusion or blood products, organ transplantation, or injection-drug use. His only international travel was a trip to the United Kingdom when he was aged 14 years. He lived with his parents and reported spending many summer nights in the back yards of his house and the houses of friends in the neighborhood. No epidemiologic or environmental investigation was performed.

Case 3. On December 15, 1998, a man aged 69 years was evaluated at a clinic in Georgia with a 1-day history of fever. CDC confirmed the diagnosis of *P. vivax* parasitemia in his blood smears. He responded well to treatment with chloroquine and primaquine.

The patient had last traveled to a malarious area 10 years before the onset of symptoms. He had no history of transfusion with blood or blood products, organ tranplantation, or injection-drug use. However, he worked as an entomologist in a laboratory where he routinely handled infecting anopheline mosquitoes. Before his infection, he was working with anopheline mosquitoes infective with a strain of *P. vivax* from southeast Asia and a West African strain of *P. ovale*. In April 1996, the patient had experienced a similar episode of probable mosquitoborne *P. vivax* malaria (*11*). In 1998, the infection was believed to have been acquired through mosquitoborne transmission in the laboratory, but was classified as cryptic because it could not be linked epidemiologically to other cases.

Induced Malaria

Case 1. On January 15, 1998, a man aged 49 years, who had a history of hypertension, sickle cell disease, and a splenectomy, had hip replacement revision surgery in Pennsylvania for avascular necrosis of the hip. He received four units of packed red blood cells during surgery, but the procedure was otherwise without complications. On February 1, he noted fever and chills. After several visits to his orthopedic clinician and two emergency department visits, he was seen again on February 19 in a hospital emergency department because of fever, hypotension, and acute renal failure. *P. falciparum* with a parasitemia of 12% was identified on blood smear. The patient was admitted to the intensive care unit (ICU) and treated with parenteral quinidine, doxycycline, and 12 units of exchange blood transfusion. Clinically, he responded well; his parasitemia decreased to 1% after 1 day of therapy, and his renal function returned to baseline after 5 days. He was discharged after 7 days.

The patient had no history of international travel or injection-drug use. He had received blood products from four separate donors in January 1998. Stored serum samples from all donors were serologically tested by using indirect fluorescent antibody test (IFA). Results from three donors were negative. One donor's (Donor N) serum demonstrated elevated titers of antibodies to malaria (*P. falciparum,* 1:16,384; *P. malariae* 1:16,384; *P. ovale* 1:1,024; and *P. vivax* 1:256). Polymerase chain reaction performed on a sample of Donor N's blood, which was taken at the time of donation, subsequently detected *P. falciparum* DNA (*12*).

On the basis of the investigation, the patient likely acquired his *P. falciparum* infection from the transfused unit of packed red blood cells donated by Donor N. Donor N was born in Nigeria, had lived in Europe, and had returned to Nigeria, where he lived for approximately 20 years before immigrating to the United States in 1996. The donor could not be located for treatment.

Deaths Attributed to Malaria

Case 1. On February 7, 1998, a man aged 42 years returned to North Carolina after a 6-month photography assignment in Zimbabwe. He reported taking no antimalarial chemoprophylaxis during his business trip. On February 11, the patient began experiencing fever, chills, and myalgia that he ascribed to a viral syndrome and influenza. He did not seek medical care during the subsequent 7 days, despite a worsening of symptoms. On February 18, after reporting not feeling well, the patient collapsed at home in his bathtub and was comatose when taken to a local hospital emergency department. He was intubated, started on dopamine and norepinephrine infusions, and underwent pericardiocentesis. He was airlifted to a nearby tertiary care center where he died from cardiac arrest soon after arrival. Results from testing performed at the emergency department revealed *P. falciparum* ring forms on blood smears and evidence of intravascular hemolysis. An autopsy report listed his cause of death as acute cerebral malaria caused by *P. falciparum*. He also had evidence of cardiomegaly, pericardial effusion, renal failure, hepatomegaly, and splenomegaly.

Case 2. On July 5, 1998, a man aged 39 years returned to Hawaii from a 2-week trip to the Philippines. He reported taking no antimalarial chemoprophylaxis during his trip. Soon after arrival, he complained of fever and chills. A diagnosis of an upper respiratory tract infection by a health-care provider was treated with an unknown antibiotic and cough preparation. On July 7, he was brought to the hospital with lethargy after a

witnessed generalized seizure at home. In the emergency department, he was unresponsive, jaundiced, and had dark-colored urine. He experienced another witnessed seizure and required intubation for respiratory support. Test results from a lumbar puncture and computed tomography (CT) scan of the head were normal, as was his complete blood count. *P. falciparum* ring forms were found on a blood smear. He was admitted to ICU and placed on intravenous quinidine.

The patient remained in the intensive care unit for a prolonged period. His parasitemia decreased after 7 days of quinidine therapy, but the patient continued to need respiratory support. The patient also received primaquine therapy. His mental status wavered, and at one point, he became alert for a short period. On July 16, he developed *Pseudomonas* pneumonia and his mental status worsened. Serial electroencephalograms (EEGs) revealed diffuse global slowing and suppression of generalized frequencies. He also required four units of packed red blood cells for severe anemia. The patient died on July 25 from pneumonia, renal failure, hepatitis, and sequelae of cerebral malaria.

Case 3. On September 1, 1998, a male resident of Ghana, aged 61 years with noninsulin-dependent diabetes mellitus and asthma, arrived in Michigan to attend his daughter's wedding. He had been out of the United States for 2 years and reported taking no malaria chemoprophylaxis. He reported taking intermittent prednisone for asthma control. On September 2, he visited a clinic in a local hospital to obtain a new glucometer and was noted to have severe rigors. He reported a 2-week history of weakness and chills that had been evaluated in Ghana and diagnosed as a viral syndrome. He was evaluated in the hospital emergency department and admitted for observation in an isolation room because he had a patchy right upper lobe infiltrate indicative of tuberculosis. He had no other symptoms, and on admission his standard laboratory test values were normal.

On September 4, hospital staff members found the patient unresponsive and incontinent in his room. He required intubation and was comatose when transferred to the intensive care unit. Blood smears taken on admission were returned at that time and revealed rare *P. falciparum* ring forms. Blood smears performed in ICU indicated a parasitemia of 25%. Intravenous quinidine was initiated, and the dose was adjusted for moderate renal failure. A head CT showed cerebral edema and a loss of gray matter/white matter distinction. Although the patient's parasitemia level decreased to 10% after 48 hours of parenteral quinidine therapy, his clinical condition did not improve, and he never regained consciousness. He died September 10.

Case 4. On November 28, 1998, a woman aged 68 years with no detailed previous medical history returned to New York City after spending 3 weeks in Liberia visiting friends and relatives. She reported taking no antimalarial chemoprophylaxis. Soon after her return, she began experiencing fevers, chills, and cough. On December 9, she sought medical attention and was prescribed amoxicillin. On December 11, she was brought to the hospital for generalized weakness and hypotension. Her diagnosis was pericarditis and IV antibiotics were administered. *P. falciparum* ring forms were identified on a blood smear performed during admission, and she was administered IV quinidine and doxycycline. She also was administered a treatment dose of mefloquine. Her condition worsened rapidly, and she was intubated for acute respiratory distress syndrome.

The patient remained in ICU for 4 weeks for respiratory support. On January 7, 1999, the patient underwent a tracheostomy procedure performed for long-term ventilatory

support. After the procedure, the patient experienced cardiovascular complications and died.

DISCUSSION

In 1998, a total of 1,227 cases of malaria were reported to CDC, a decrease from the 1,544 cases reported for 1997. This change resulted primarily from a decrease in cases acquired in Asia that might have resulted from decreased reporting, immigration, international travel, and transmission; and change in travel patterns, or increased use of effective antimalarial chemoprophylaxis.

One reason for conducting malaria surveillance is to monitor the emergence of drug resistance and the consequent failure of chemoprophylaxis. However, approximately 73% of imported malaria cases among U.S. civilians occurred in persons who were either not taking chemoprophylaxis or were taking chemoprophylaxis regimens not recommended for the region they were traveling to or from. Of the 155 persons who reported taking recommended chemoprophylaxis, 123 cases (i.e., 68 *P. vivax,* 27 *P. falciparum*, 19 unknown species, 4 *P. ovale*, 4 *P. malariae,* and 1 mixed infection), insufficient information was available to determine whether cases represented persons not completing antimalarial chemoprophylaxis as recommended, errors made by health-care workers or laboratory staff members, or emerging drug resistance. However, no conclusive evidence existed to indicate a single national or regional source of infection among this group of patients.

The importance of taking proper precautions and chemoprophylaxis is indicated by the four deaths attributed to malaria in the United States in 1998. None of the patients had taken prophylaxis; two had substantial delays in seeking care; and three were treated for a nonmalaria illness before it was determined they had malaria. This pattern is consistent with previous findings from a review of deaths attributed to malaria in the United States (*13*).

Signs and symptoms of malaria can be vague, but fever is generally 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 infection in a febrile person with a recent history of travel to a malarious area. Clinicians should ask febrile patients for a travel history, particularly when evaluating febrile illnesses in international visitors, immigrants, refugees, migrant laborers, and international travelers.

Treatment for malaria should be initiated immediately after the diagnosis has been confirmed by a positive blood smear. 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*). Although non-*falciparum* malaria rarely causes complications, *P. falciparum* malaria can cause severe, life-threatening complications.

Health-care workers are encouraged to consult appropriate sources for malaria treatment recommendations and suspected chemoprophylaxis failure or call CDC's National Center for Infectious Diseases, Division of Parasitic Diseases, Malaria Epidemiology Branch. Detailed recommendations for preventing malaria are available 24 hours a day by calling 877-FYI-TRIP or from the CDC Traveler's Health website at <http://www.cdc.gov/travel>. In addition, CDC publishes annually updated recommendations in *Health Information for International Travel* (*9*) (Box).

BOX. CDC sources for malaria chemoprophylaxis and treatment recommendations

Type of information	Source	Time available	Number to call
Prophylaxis	CDC Traveler's Health Voice Information System	24 hours/day	877-394-8747
Prophylaxis	CDC Traveler's Health Facsimile	24 hours/day	888-232-3299
Prophylaxis	CDC Traveler's Health Internet home page	24 hours/day	http://www.cdc.gov/travel/
Prophylaxis	*Health Information for International Travel*	Order from Superintendent of Documents US Government Printing Office Washington, DC 20402-9235	202-512-1800
Treatment*	CDC Malaria Epidemiology Branch	8:00 AM to 4:30 PM EST, Monday through Friday	770-488-7788
Treatment (after hours)*	CDC Malaria Epidemiology Branch	4:30 PM to 8:00 AM EST, weekends and holidays	404-639-2888 (Ask operator to page person on call for Malaria Epidemiology Branch.)

*Number intended for use by health-care professionals only.

Acknowledgment

The authors thank state health departments, health-care providers, and laboratories for reporting this information to CDC.

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APPENDIX

Microscopic Procedures for Diagnosing Malaria

To establish the diagnosis of malaria, a blood smear must be prepared from fresh blood obtained by pricking the finger (Figures A–1 and A–2).* The thin smear is fixed in methanol before staining; the thick smear is stained unfixed. Many hospitals have a Wright-Giemsa stain available, which is acceptable; however, Wright stain alone will not reliably show *Plasmodium* parasites. For best results, the smear 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 smears are more sensitive in detecting malaria parasites because the blood is concentrated, allowing a greater volume of blood to be examined. However, thick smears are more difficult to read, and thin smears may be preferred by laboratories that have limited experience. *Plasmodium* parasites are always intracellular, and

*In Figures A-1 and A-2, the hands are shown ungloved to better illustrate 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 film.

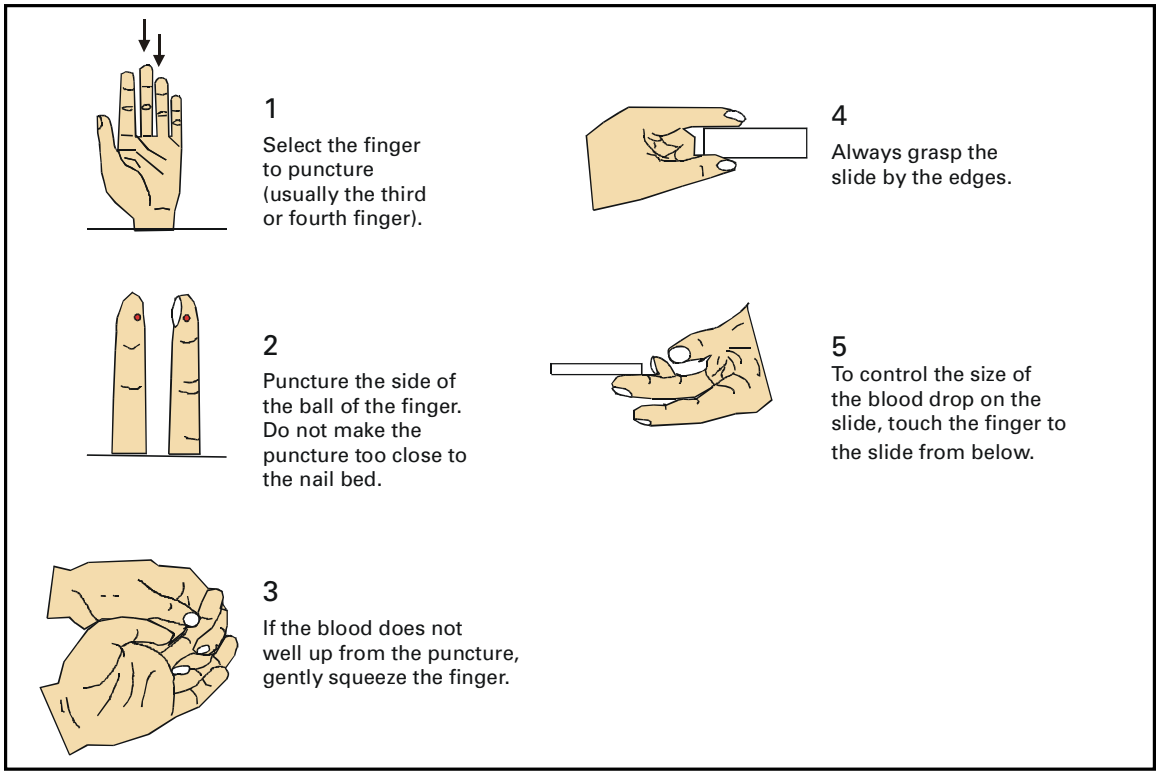
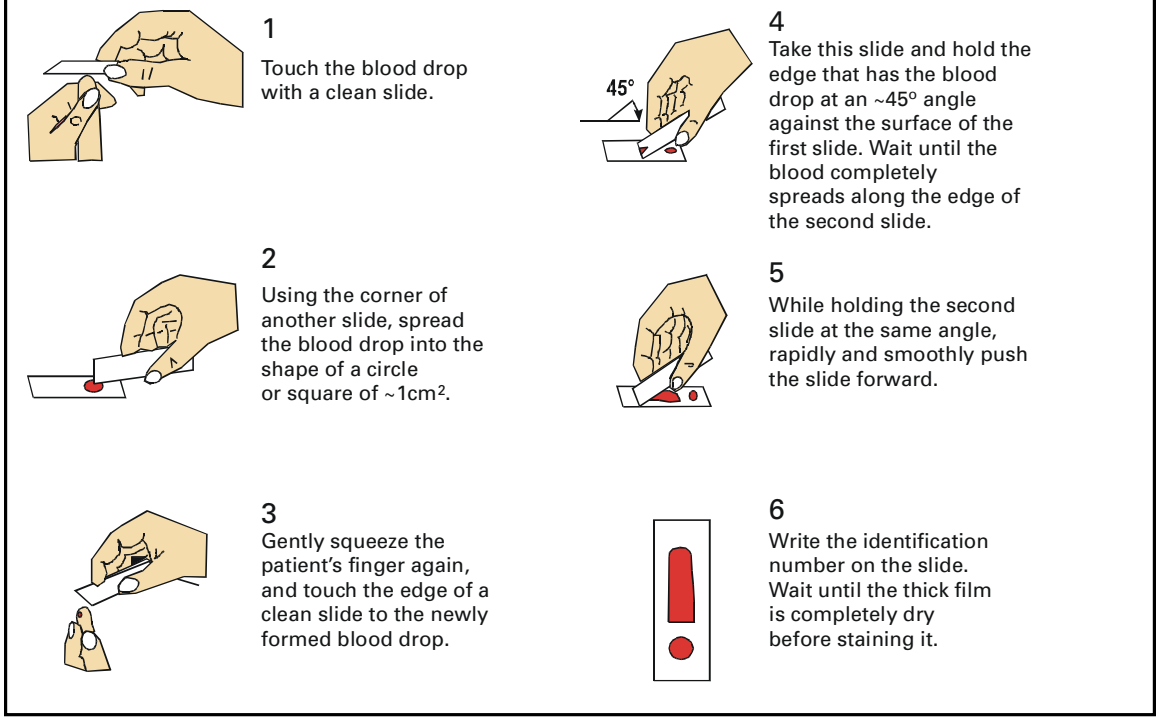


Figure A-2. Preparation of a thin and a thick blood film on the same slide.



they demonstrate, if stained correctly, blue cytoplasm with a red chromatin dot. Common errors in reading malaria smears are caused by platelets overlying a red blood cell, concern about missing a positive slide, and misreading artifacts as parasites. Persons suspected of having malaria but whose blood smears do not show the presence of parasites should have blood smears repeated approximately every 12–24 hours for 3 consecutive days. If smears remain negative, then the diagnosis of malaria is unlikely.

For rapid diagnosis, make thick and thin smears on separate slides. Air dry the thin film, fix it with methyl alcohol, and immediately stain it. If no parasites are found on the thin film, wait until the thick film is dry and examine it for organisms that might not have been detected on the thin preparation.

State and Territorial Epidemiologists and Laboratory Directors

State and Territorial Epidemiologists and Laboratory Directors are acknowledged for their contributions to *CDC Surveillance Summaries*. The epidemiologists and the laboratory directors listed below were in the positions shown as of October 2001.

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