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Malaria Surveillance — United States, 2010

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Front cover photo: Female scientist looking through a microscope (Photo/CDC)

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Malaria Surveillance — United States, 2010

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Abstract

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

Period Covered: This report summarizes cases in persons with onset of illness in 2010 and summarizes trends during previous years.

Description of System: Malaria cases diagnosed by blood film, polymerase chain reaction, or rapid diagnostic tests are mandated to be 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), National Notifiable Diseases Surveillance System (NNDSS), or direct CDC consults. Data from these reporting systems serve as the basis for this report.

Results: CDC received 1,691 reported cases of malaria, including 1,688 cases classified as imported, one transfusion-related case, and two cryptic cases, with an onset of symptoms in 2010 among persons in the United States. The total number of cases represents an increase of 14% from the 1,484 cases reported for 2009. *Plasmodium falciparum*, *P. vivax*, *P. malariae*, and *P. ovale* were identified in 58%, 19%, 2%, and 2% of cases, respectively. Thirteen patients were infected by two or more species. The infecting species was unreported or undetermined in 18% of cases. Among the 898 cases in U.S. civilians for whom information on chemoprophylaxis use and travel area was known, 45 (5%) reported that they had followed and adhered to a chemoprophylactic drug regimen recommended by CDC for the areas to which they had traveled. Forty-one cases were reported in pregnant women, among whom only two (5%) adhered to chemoprophylaxis. Among all reported cases, 176 (10%) were classified as severe infections, of which nine were fatal.

Interpretation: The number of cases reported in 2010 marked the largest number of cases reported since 1980. Despite the apparent progress in reducing the global burden of malaria, many areas remain malaria endemic and the use of appropriate prevention measures by travelers is still inadequate.

Public Health Actions: Travelers visiting friends and relatives (VFR) continue to be a difficult population to reach with effective malaria prevention strategies. Evidence-based prevention strategies that effectively target VFR travelers need to be developed and implemented to have a substantial impact on the numbers of imported malaria cases in the United States. A large number of pregnant travelers diagnosed with malaria did not take any chemoprophylaxis. Pregnant women traveling to areas in which malaria is endemic are at higher risk for severe malaria and must use appropriate malaria prevention strategies including chemoprophylaxis. Malaria prevention recommendations are available online (http://www.cdc.gov/malaria/travelers/drugs.html). Malaria infections can be fatal if not diagnosed and treated promptly with antimalarial medications appropriate for the patient's age and medical history, the likely country of malaria acquisition, and previous use of antimalarial chemoprophylaxis. Clinicians should consult the CDC Guidelines for Treatment of Malaria and contact the CDC's Malaria Hotline for case management advice, when needed. Malaria treatment recommendations can be obtained online (http://www.cdc.gov/malaria/diagnosis_treatment) or by calling the Malaria Hotline (770-488-7788 or toll-free at 855-856-4713).

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Introduction

Malaria in humans is caused by infection with one or more of several species of *Plasmodium* (i.e., *P. falciparum*, *P. vivax*, *P. ovale*, *P. malariae*, and occasionally other *Plasmodium* species). The infection is transmitted by the bite of an infective female *Anopheles* mosquito. *P. falciparum* and *P. vivax* species cause the most infections worldwide. *P. falciparum* is the agent that most commonly causes severe and potentially fatal malaria (see Definitions). Worldwide, an estimated 216 million clinical cases and 655,000 deaths were reported in 2010, mostly in children aged <5 years living in sub-Saharan Africa (*1*). *P. vivax* and *P. ovale* have dormant liver stages, which can reactivate and cause malaria several months or years after the initial infection. *P. malariae* can result in long-lasting infections and if untreated can persist asymptomatically in the human host for years, even a lifetime (*1*). Approximately half of the world's population live in areas where malaria is transmitted (i.e., approximately 100 countries in parts of Africa, Asia, the Middle East, Eastern Europe, Central and South America, the Caribbean, and Oceania). Before the 1950s, malaria was endemic throughout the southeastern United States; an estimated 600,000 cases occurred in 1914 (*2*). During the late 1940s, a combination of improved housing and socioeconomic conditions, environmental 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 instances of local transmission and to monitor patterns of resistance to antimalarial drugs. Malaria vector mosquitoes are still present in the United States.

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

State and local health departments and CDC investigate reported malaria cases in the United States, and CDC analyzes data from imported cases to detect trends in acquisition. This information is used to guide malaria prevention recommendations for international travelers.

The signs and symptoms of malaria illness are varied, but the majority of patients have fever. Other common symptoms include headache, back pain, chills, increased sweating, myalgia, nausea, vomiting, diarrhea, and cough. A diagnosis of malaria should always be considered for persons with these symptoms who have traveled to an area with known malaria transmission. Malaria also should be considered in the differential diagnosis of persons who have fever of unknown origin, regardless of their travel history. Untreated infections can rapidly progress to coma, renal failure, respiratory distress, and death. This report summarizes malaria cases reported to CDC among persons with onset of symptoms in 2010.

Methods

Data Sources

Malaria case data are reported to the National Malaria Surveillance System (NMSS) and the National Notifiable Diseases Surveillance System (NNDSS) (*4*). Although both systems rely on passive reporting, the numbers of reported cases might vary because of differences in collection and transmission of data. A substantial difference between 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). Malaria cases can be reported to CDC through either the NMSS or the NNDSS, or through direct consultation with CDC malaria staff; therefore, cases reported through these various paths are compared, de-duplicated, compiled, and analyzed. Additionally, the Armed Forces Health Surveillance Center (AFSHC) provided information about additional military cases that were not reported to state health departments and those were added to the NMSS database. This report presents data on the aggregate of cases reported to CDC through all reporting systems.

Malaria cases are categorized by infecting species: *Plasmodium falciparum*, *P. vivax*, *P. malariae*, *P. ovale.* When more than a single species is detected, the case is categorized as a mixed infection. All categories are mutually exclusive. Diagnosis of malaria is confirmed by bloodfilm or polymerase chain reaction (PCR). A rapid diagnostic test (RDT) can be used to diagnose malaria; however, it must be confirmed by either microscopy or PCR to be counted as a case. Each confirmed malaria case is reported by health-care providers or laboratories to local or state health departments and to CDC. CDC staff review all reports 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 to CDC directly by health-care providers, usually when they are seeking assistance with diagnosis or treatment. Information regarding cases reported directly to CDC is shared with the relevant state health department. All possible cases that have been reported as acquired in the United States are investigated further, including all induced, congenital, introduced, and cryptic cases (see Definitions). Information derived from uniform case report forms is entered

*The term United States includes all U.S. states and territories.

into a database and analyzed annually (http://www.cdc.gov/malaria/resources/pdf/report/malaria_form.pdf).

The chi-square test was used to calculate p values and assess differences between variables reported in 2010 compared with previous years. A p value of <0.05 was considered statistically significant.

Definitions

The following definitions are used in malaria surveillance for the United States:

- **U.S. residents** — Persons residing in the United States, including both civilian and U.S. military personnel, regardless of legal citizenship.
- **U.S. civilians** — Any U.S. residents, excluding U.S. military personnel.
- **Foreign residents** — Persons who hold resident status in a country other than the United States.
- **Travelers visiting friends or relatives** — Immigrants, ethnically and racially distinct from the major population of the country of residence (a country where malaria is not endemic), who return to their homeland (a country where malaria is endemic) to visit friends or relatives. Included in the VFR category are family members (e.g., spouse or children) who were born in the country of residence.
- **Laboratory criteria for diagnosis:** Demonstration of malaria parasites on blood film, PCR, or by RDT (followed by blood film confirmation).
- **Confirmed case:** Symptomatic or asymptomatic infection that occurs in a person in the United States or one of its territories who has laboratory-confirmed (by microscopy or PCR) 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, regardless of indicated *Plasmodium* species, unless the case is indicated as a treatment failure resulting from drug resistance.

This report also uses terminology derived from the recommendations of the World Health Organization (*5*). 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 a person with 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.
- **Induced malaria:** Malaria acquired through artificial means (e.g., blood transfusion, organ transplantation, or by using shared syringes).
- **Relapsing malaria:** Recurrence of disease after it has been apparently cured. In malaria, true relapses are caused by reactivation of dormant liver-stage parasites (hypnozoites) of *P. vivax* and *P. ovale*.
- **Severe malaria:** A case of malaria with one or more of the following manifestations: neurologic symptoms, renal failure, severe anemia (defined by hemoglobin [Hb] <7g/dL), acute respiratory distress syndrome (ARDS), jaundice, or ≥5% parasitemia (*6*). To attempt to include severe cases in which clinical criteria were not reported, persons who were treated for severe malaria (i.e., artesunate, quinidine, and/or an exchange blood transfusion) despite having no specific severe manifestations reported also are counted as a severe case in this analysis.
- **Cryptic malaria:** A case of malaria for which epidemiologic investigations fail to identify a plausible mode of acquisition (this term applies primarily to cases found in countries where malaria is not endemic).

Laboratory Diagnosis of Malaria

To diagnose malaria early and promptly, physicians must obtain a travel history from every febrile patient. Malaria should be included in the differential diagnosis of every febrile patient who has traveled to a malarious area. If malaria is suspected, a Giemsa-stained film of the patient's peripheral blood should be examined for parasites as soon as possible. Thick and thin blood films must be prepared correctly because diagnostic accuracy depends on bloodfilm quality and examination by experienced laboratory personnel (*7*). Some reference laboratories and health departments can diagnose malaria using PCR, although this is generally reserved for cases for which bloodfilm diagnosis of malaria is inadequate and for confirmation of species. PCR results are also often not available quickly enough to be of use in the initial diagnosis and treatment of a patient with malaria.

In addition, BinaxNOW Malaria, an RDT that detects circulating malaria-specific antigens, is widely available for use by U.S. laboratories. The test is only approved for use by hospital and commercial laboratories, not by individual clinicians or the general public (*7*). In the United States, use of RDTs can decrease the amount of time required to determine whether a patient is infected with malaria but does not eliminate the need for standard tests (*8*). RDTs are not able to speciate or quantify malaria parasites (*9*). Positive and negative RDTs must be confirmed by microscopy.

Results

General Surveillance

In 2010, CDC received 1,691 reports concerning cases of malaria among persons in the United States, representing a 14% increase from the 1,484 cases reported with onset of symptoms in 2009. Additionally, the number of cases reported in 2010 are the largest number of malaria cases that have been reported in the United States since 1980 (N = 1,864). In 2010, a total of 1,131 cases occurred among U.S. residents, 368 cases among foreign residents, and 192 cases among patients with unknown or unreported resident status (Table 1). The proportion of cases with unknown resident status decreased 68% from 2009 to 2010.

Plasmodium Species

Among the 1,691 cases reported in 2010, the infecting species of *Plasmodium* was identified and reported in 1,388 (82%) cases; a significant improvement in species identification by 52% compared with 2009 (Table 2) (*7*). *P. falciparum* and *P. vivax* comprised the majority of infections and were identified in 71% and 23% of infected persons with species reported, respectively. Among 1,366 cases for which both the region of acquisition and the infecting species were known, *P. falciparum* accounted for 86% of infections acquired in Africa, 81% in the Americas, 9% in Asia, and 40% in Oceania. Infections attributed to *P. vivax* accounted for 6% acquired in Africa, 16% in the Americas, 87% in Asia, and 60% in Oceania.

Region of Acquisition and Diagnosis

Among the 1,691 reported cases, 1,688 were classified as imported cases; one transfusion–related case and two cryptic cases were reported. Information on region of acquisition was known for 88% of the imported cases, a significant increase of 50% from 2009 (*7*). Of 1,479 imported cases for which the region of acquisition was known, 959 (65%) were acquired in Africa, 285 (19%) in Asia, 230 (15%) in the Americas, and five (0.3%) in Oceania (Table 3). West Africa accounted for 700 (73%) cases acquired in Africa, where cases acquired in Ghana increased by 72% compared with 2009. In Asia, 268 (94%) cases were acquired in South Asia, of which 216 (81%) were acquired in India. This represents a significant 57% increase in the number of reported cases acquired in India from 2009. The Caribbean region accounted for 77% (n = 178) of the cases in the Americas, of which 96% (n = 171) were from Haiti. This represents a significant 66% increase in the number of reported cases acquired in Haiti from 2009. Information regarding region of acquisition was missing for 209 (12%) imported cases (Table 3).

TABLE 1. Number of malaria cases* among U.S. military personnel and U.S. and foreign civilians — United States, 1980–2010

Year	U.S. military personnel	U.S. civilians	Foreign residents	Status not recorded	Total
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**
2002	33	849	272	183	**1,337**
2003	36	767	306	169	**1,278**
2004	32	775	282	235	**1,324**
2005	36	87	297	325	**1,528**
2006	50	736	217	561	**1,564**
2007	33	701	263	508	**1,505**
2008	19	510	176	593	**1,298**
2009	18	661	201	604	**1,484**
2010	46	1,085	368	192	**1,691**

* A case was defined as symptomatic or asymptomatic illness that occurs in the United States or one of its territories in a person who has laboratory-confirmed malaria parasitemia (microscopy or polymerase chain reaction), regardless of whether the person had previous episodes of malaria while in other countries. A subsequent episode of malaria occurring in a person is counted as an additional case if the demonstrated *Plasmodium* species differs from the initially identified species or if it is indicated as a relapsing infection demonstrating *Plasmodium* species is the same species identified previously. If a subsequent episode of malaria occurs as a result of a drug resistance failure, then the case is not counted as an additional case.

TABLE 2. Number and percentage of malaria cases, by *Plasmodium* species — United States, 2008–2010

Plasmodium species	2008		2009		2010	
	No.	(%)	No.	(%)	No.	(%)
P. falciparum	527	(40.6)	687	(46.3)	982	(58.1)
P. vivax	190	(14.6)	166	(11.2)	325	(19.2)
P. malariae	19	(1.5)	32	(2.1)	35	(2.1)
P. ovale	18	(1.4)	29	(2.0)	33	(1.9)
P. knowlesi	1	(0.1)	0	(0)	0	(0)
Mixed	8	(0.6)	13	(0.9)	13	(0.8)
Undetermined	535	(41.2)	557	(37.5)	303	(17.9)
Total	**1,298**	**(100)**	**1,484**	**(100)**	**1,691**	**(100)**

TABLE 3. Number of imported malaria cases, by country of acquisition and *Plasmodium* species — United States, 2010

Country of acquisition	*P. falciparum*	*P. vivax*	*P. malariae*	*P. ovale*	Unknown	Mixed	Total
Africa	**763**	**58**	**25**	**28**	**76**	**9**	**959**
Angola	3	0	1	0	0	0	**4**
Benin	4	0	0	0	1	0	**5**
Burkina Faso	22	0	2	0	1	0	**25**
Burundi	1	0	0	0	0	0	**1**
Cameroon	31	0	1	2	2	0	**36**
Central African Republic	1	0	0	0	0	0	**1**
Congo, Republic of	4	1	1	0	0	0	**6**
Côte d'Ivoire	33	0	2	0	4	0	**39**
Equatorial Guinea	1	0	0	0	0	0	**1**
Eritrea	0	5	0	0	1	0	**6**
Ethiopia	6	31	0	1	4	1	**43**
Gambia	9	0	0	0	0	0	**9**
Ghana	155	2	3	3	6	1	**170**
Guinea	27	0	1	1	0	0	**29**
Kenya	12	2	3	2	3	0	**22**
Liberia	46	0	0	2	5	1	**54**
Madagascar	1	0	0	1	0	0	**2**
Malawi	5	1	0	0	0	0	**6**
Mali	11	1	0	0	1	0	**13**
Mauritania	1	1	0	0	1	0	**3**
Mozambique	1	0	0	0	2	0	**3**
Niger	1	0	0	0	0	0	**1**
Nigeria	219	0	3	8	8	2	**240**
Rwanda	0	1	0	0	0	0	**1**
Senegal	12	0	0	0	0	0	**12**
Sierra Leone	58	0	4	0	8	0	**70**
South Africa	2	0	0	0	2	0	**4**
Sudan	11	2	1	1	2	1	**18**
Tanzania	3	0	0	1	0	1	**5**
Togo	9	0	0	0	2	0	**11**
Uganda	23	5	1	5	7	1	**42**
Zambia	2	0	0	0	0	0	**2**
Zimbabwe	1	0	0	0	0	0	**1**
West Africa, unspecified	17	0	1	0	0	0	**18**
East Africa, unspecified	9	3	1	1	1	0	**15**
Southern Africa, unspecified	1	0	0	0	0	0	**1**
Africa, unspecified	21	3	0	0	15	1	**40**

Table continued on page 6.

In the United States, six reporting areas accounted for 50% of the reported malaria cases: New York City (n = 278), Florida (n = 142), California (n = 122), New Jersey (n = 109), Texas (n = 100), and Maryland (n = 95) (Figure 1). The state with the most significant change in reported malaria cases in 2010 was Florida, which increased by 51% from 2009, likely because of the significant increase in the number of cases that were acquired in Haiti that were reported in Florida in 2010 compared with 2009.

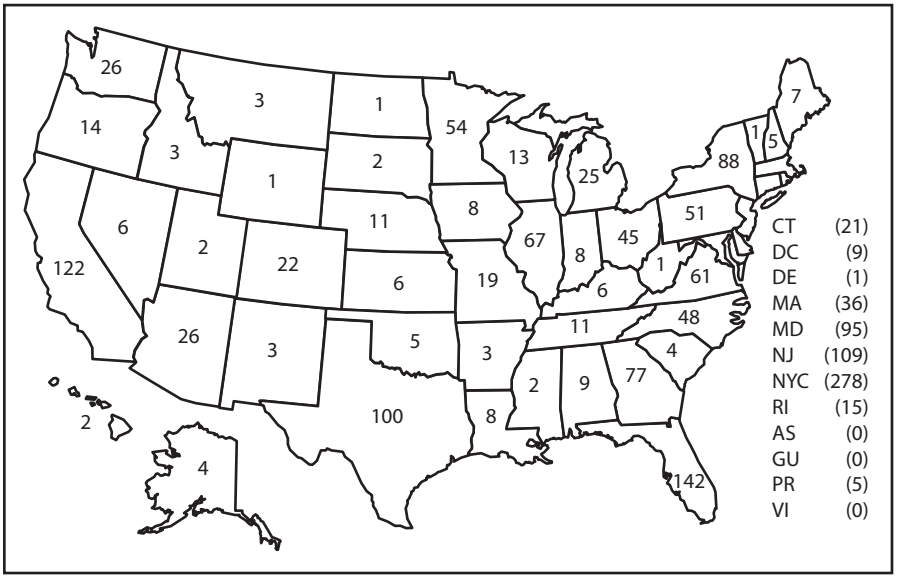
Imported Malaria by Resident Status

Among the 1,496 imported malaria cases of known resident status, 1,129 (75%) occurred among U.S. residents and 367 (25%) among residents of other countries. Among the 1,129 imported malaria cases among U.S. residents, 724 (64%) were acquired in Africa, 179 (16%) were acquired in the Americas, and 173 (15%) were acquired in Asia (Table 4). This represents a significant increase of cases among U.S. residents in all three regions compared with 2009. No significant change was noted in the cases acquired in Oceania between 2009 and 2010. Of the 367 imported cases among foreign residents, 213 (58%) were acquired in Africa, a significant increase of 61% from 2009. Among imported cases among foreign residents, 45 (12%) cases were acquired in the Americas, and 108 (29%) were acquired in Asia. Among those foreign cases in persons for whom purpose of visit was known, 177 (48%) occurred in recent immigrants or refugees, with approximately half coming from Africa, and 84 (23%) occurred in foreign residents who traveled to the United States to visit friends and relatives.

TABLE 3. (*Continued*) Number of imported malaria cases, by country of acquisition and *Plasmodium* species — United States, 2010

Country of acquisition	*P. falciparum*	*P. vivax*	*P. malariae*	*P. ovale*	Unknown	Mixed	Total
Asia	**22**	**222**	**8**	**2**	**28**	**3**	**285**
Afghanistan	0	22	2	0	0	0	**24**
Bhutan	0	1	0	0	0	0	**1**
Burma (Myanmar)	1	2	0	0	1	0	**4**
Cambodia	0	0	1	0	0	0	**1**
India	14	170	4	2	23	3	**216**
Indonesia	1	1	0	0	0	0	**2**
Korea, South	0	3	0	0	0	0	**3**
Nepal	0	3	0	0	0	0	**3**
Pakistan	2	14	1	0	3	0	**20**
Philippines	0	1	0	0	0	0	**1**
Thailand	4	4	0	0	0	0	**8**
Asia, unspecified	0	1	0	0	1	0	**2**
Central America and the Caribbean	**174**	**18**	**1**	**1**	**5**	**1**	**200**
Dominican Republic	6	0	0	0	0	0	**6**
Guatemala	0	5	0	0	0	0	**5**
Haiti	166	0	1	0	3	1	**171**
Honduras	0	11	0	1	0	0	**12**
Mexico	1	2	0	0	1	0	**4**
Nicaragua	0	0	0	0	1	0	**1**
Caribbean, unspecified	1	0	0	0	0	0	**1**
South America	**6**	**17**	**1**	**2**	**4**	**0**	**30**
Brazil	0	2	0	0	1	0	**3**
Guyana	5	6	1	2	1	0	**15**
Peru	0	5	0	0	1	0	**6**
Venezuela	0	1	0	0	1	0	**2**
South America, unspecified	1	3	0	0	0	0	**4**
Oceania	**2**	**3**	**0**	**0**	**0**	**0**	**5**
Papua New Guinea	2	3	0	0	0	0	**5**
Unknown	**12**	**7**	**0**	**0**	**190**	**0**	**209**
Total	**979**	**325**	**35**	**33**	**303**	**13**	**1,688**

FIGURE 1. Number of malaria cases (N = 1,691) among people type, by state or territory — United States, 2010



Abbreviations: AS = American Samoa; GU = Guam; PR = Puerto Rico; VI = U.S. Virgin Islands.

Seasonality of Malaria Diagnosed in the United States

The majority of cases reported in the United States among persons who indicated travel to Africa peaked in January and July (Figure 2), and were primarily *P. falciparum* (Figure 3). These peaks likely correlated with peak travel times to African destinations related to winter and early summer holidays. The majority of cases reported in the United States among those who indicated travel to Asia (most of whom had traveled to India) peaked in August, followed by a smaller peak in November (Figure 2). Correspondingly, the majority of reported *P. vivax* cases also peaked around August followed by a smaller peak in November. Additionally, a slight peak occurred around April (Figure 3).

Interval Between Arrival in the United States and Illness Onset

Among the 1,388 imported malaria cases with an identified *Plasmodium* species, the interval between both the date of arrival in the United States and onset of illness was known for 1,002 (59%) cases. Onset of symptoms began before arrival in the United States for 109 (11%) patients; the remaining 893 (89%) patients experienced malaria symptoms on or after arrival to the United States. Onset of malaria symptoms occurred <1 month after arrival in 632 (84%) of the 753 *P. falciparum* patients and in 117 (59%) of the 197 *P. vivax* patients (Table 5).

Imported Malaria Among U.S. Military Personnel

In 2010, a total of 46 cases of imported malaria were reported among U.S. military personnel, a significant increase from 2009. Nineteen persons reported travel to Afghanistan, eight to Haiti, and six to various regions in Africa. One reported travel to South Korea and one to South America. Region of travel was unspecified in 11 persons. Information on infecting species was known for 39 cases; 14 cases were identified as *P. falciparum*, 23 cases as *P. vivax*, one case as *P. malariae*, and one case as a mixed infection. Among those 39 cases, 28 occurred in persons who reported having taken an appropriate drug for primary chemoprophylaxis. However, among the 16 patients infected with *P. vivax*, five reported taking primaquine for presumptive antirelapse therapy, which also was indicated in these instances. Of the 46 cases among U.S. military personnel, only seven (15%) patients reported adherence (no missed doses) to the prescribed drug regimen.

Chemoprophylaxis Use Among U.S. Civilians

Information about chemoprophylaxis use and travel area was known for 898 (83%) of the 1,083[†] U.S. civilians who had imported malaria. Of these 898 persons, 228 (25%) had taken chemoprophylaxis, a proportion that is similar to 2009. Among the 228 persons who reported taking malaria chemoprophylaxis, 72 (32%) did not report specific drug type taken, if any. Of the remaining 156 persons, 25 (16%) had taken a medication that is not recommended by CDC for the area visited, and 131 (84%) had taken a CDC-recommended medication. Of the 131 who reported taking CDC-recommended chemoprophylaxis, 50 (38%) had taken mefloquine, 49 (37%) had taken doxycycline, 22 (17%) had

[†] One transfusion and two cryptic cases were excluded from the total number of imported U.S. civilian cases.

TABLE 4. Number and percentage of imported malaria cases among U.S. and foreign residents, by region of acquisition — United States, 2010*

	United States		Foreign		Total	
Area or region	**No.**	**(%)**	**No.**	**(%)**	**No.**	**(%)**
Africa	724	(64.1)	213	(58.0)	**937**	**(62.6)**
Asia	173	(15.3)	108	(29.4)	**281**	**(18.8)**
Central America/ Caribbean	154	(13.6)	41	(11.2)	**195**	**(13.0)**
South America	25	(2.3)	4	(1.1)	**29**	**(1.9)**
Oceania	5	(0.4)	0	(0.0)	**5**	**(0.4)**
Unknown	48	(4.3)	1	(0.3)	**49**	**(3.3)**
Total	**1129**	**(100.0)**	**367**	**(100.0)**	**1496**	**(100.0)**

* Persons for whom U.S. or foreign status is not known are excluded.

FIGURE 2. Number of malaria cases, by region and month, 2010

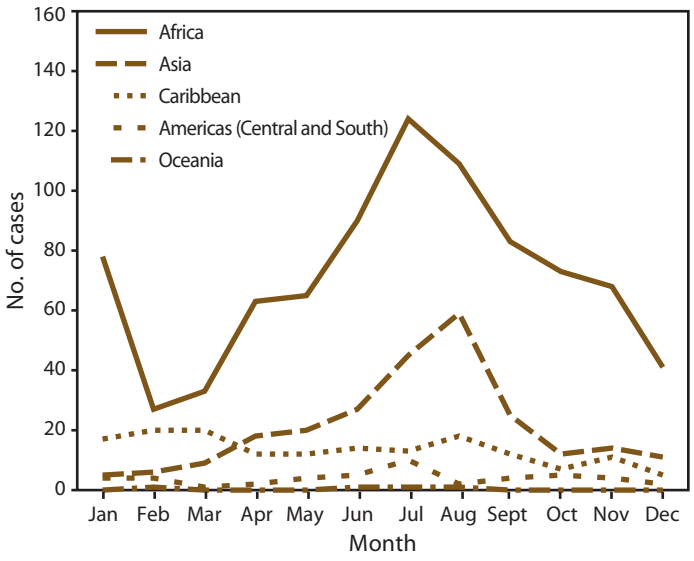
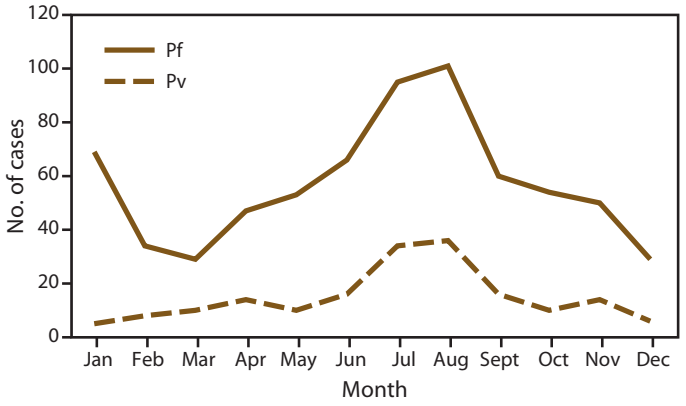


FIGURE 3. Number of malaria cases, by species and month, 2010



Abbreviations: Pf = *P. falciparum*; Pv = *P. vivax*.

TABLE 5. Number and percentage of imported malaria cases, by interval between date of arrival in the United States and onset of illness and *Plasmodium* species* — United States, 2010

	P. falciparum		*P. vivax*		*P. malariae*		*P. ovale*		Mixed		Total	
Interval (days)	No.	(%)	No.	(%)	No.	(%)	No	(%)	No	(%)	No.	(%)
<0†	82	(10.9)	24	(12.2)	2	(8.0)	1	(5.3)	0	(0.0)	**109**	**(10.9)**
0–29	632	(83.8)	117	(59.4)	15	(60.0)	7	(36.8)	8	(100.0)	**779**	**(77.7)**
30–89	29	(3.9)	24	(12.2)	7	(28.0)	3	(15.8)	0	(0.0)	**63**	**(6.3)**
90–179	5	(0.7)	21	(10.6)	1	(4.0)	6	(31.5)	0	(0.0)	**33**	**(3.3)**
180–364	5	(0.7)	11	(5.6)	0	(0.0)	1	(5.3)	0	(0.0)	**17**	**(1.7)**
>365	0	(0.0)	0	(0.0)	0	(0.0)	1	(5.3)	0	(0.0)	**1**	**(0.1)**
Total	**753**	**(100.0)**	**197**	**(100.0)**	**25**	**(100.0)**	**19**	**(100.0)**	**8**	**(100.0)**	**1,002**	**(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.
† Cases in this row are in patients who had onset of illness before arriving in the United States.

taken atovaquone/proguanil, none had taken primaquine, and five (4%) had taken chloroquine. Five additional patients had taken a combination of two CDC-recommended malaria chemoprophylaxis medications for the specific travel region. Information about infecting species was available for 120 (92%) patients who had taken a recommended antimalarial drug and was undetermined for the remaining 11 patients. Moreover, among the 113 who reported taking CDC-recommended chemoprophylaxis and for whom adherence was known, 60% (n = 68) reported nonadherence (i.e., missed doses).

Cases of P. vivax *or* P. ovale *After Recommended Prophylaxis Use.* Among the 120 patients who took chemoprophylaxis appropriately and had information on infecting species, 22 (18%) cases were caused by *P. vivax*, and 10 (8%) cases were caused by *P. ovale*. Of the 32 cases of *P. vivax* or *P. ovale*, information on eight cases was insufficient (i.e., missing data regarding symptom onset or return date from travel) to assess a relapse infection. Twelve cases occurred >45 days after the patient arrived in the United States. These cases were consistent with relapsing infections and do not indicate primary prophylaxis failures. Six cases occurred ≤45 days after the patient returned to the United States. Among the six patients, two were nonadherent with their malaria chemoprophylaxis regimen and two did not provide adherence information. The remaining two patients, who reported adherence with an antimalarial chemoprophylaxis regimen, had traveled to Africa and India, and had taken atovaquone/proguanil and mefloquine, respectively, for malaria chemoprophylaxis. Possible explanations for these cases include inappropriate dosing, unreported nonadherence, malabsorption of the drug, an early relapse from hypnozoites established at the start of this trip, or possibly emerging parasite resistance.

Cases of P. falciparum *or* P. malariae *After Recommended Prophylaxis Use.* The 120 cases of malaria reported among persons who had taken a recommended antimalarial drug for chemoprophylaxis included 80 cases of *P. falciparum* and seven cases of *P. malariae*. Of the 80 *P. falciparum* cases, 69 (86%) were acquired in Africa and seven (9%) cases were acquired in Haiti. Fifty-one (64%) of the 80 *P. falciparum* patients reported nonadherence to the antimalarial drug regimen, and 10 patients had no adherence information available. In 19 (24%) cases, patients reported adherence with antimalarial chemoprophylaxis, of which 14 (74%) had traveled to Africa (seven patients took mefloquine, five took doxycycline, and two took atovaquone/proguanil), and three (16%) traveled to Haiti (two patients took chloroquine and one took doxycycline). Of the seven *P. malariae* cases, three reported adherence to the antimalarial drug regimen, of which all had traveled to Africa (two patients took mefloquine and one took atovaquone/proguanil).

Patients with a Recent History of Malaria

Of the 1,688 imported cases, data on history of malaria was known for 1,173 (69%) cases; 183 (16%) patients reported a history of a malaria infection during the preceding 12 months. Among the 183 cases, 65 (36%) were caused by *P. vivax* and eight (4%) by *P. ovale*, and 19 (10%) reported no species. A total of 11 probable relapses were identified based on onset date, date of previous infection, and previous infection species type: 10 *P. vivax* cases and one *P. ovale* case. Among the 11 relapses, six patients (five had a *P. vivax* infection and one had a *P. ovale* infection) received primaquine for the most recent infection to avoid future relapses.

Purpose of Travel

Purpose of travel to areas in which malaria is endemic was reported for 828 (76%) of the 1,083 U.S. civilians with imported malaria (Table 6). Of the 828 who reported purpose of travel, the largest proportion (71%) was VFR travelers; the second and third largest proportions, 9% and 8%, were persons who had traveled as missionaries or on business, respectively.

TABLE 6. Number and percentage of imported malaria cases (N=1,083) among U.S. civilians, by purpose of travel at the time of acquisition — United States, 2010

Category	No.	(%)
Visiting friends and relatives	586	(54)
Tourist	43	(4)
Missionary or dependent	75	(7)
Business representative	65	(6)
Student or teacher	38	(3)
Air crew or sailor	9	(1)
Other	12	(1)
Unknown	255	(24)

The proportions of purpose for travel in all categories in 2010 were similar to 2009; however, the proportion of patients who traveled for tourism continued on a downward trend that began in 2007. No significant association was found between purpose of travel and geographic region or species type.

Malaria by Age

Among the 1,573 cases among patients for whom age was known, 232 (15%) occurred in persons aged <18 years, 1,260 (80%) in persons aged 18–64 years, and 81 (5%) in persons aged ≥65 years. Although the majority of cases occur in persons aged 18–64 years, pediatric cases are of particular interest because the preventive care of most children is determined by parents or guardians. Among the 232 cases among persons aged <18 years, 108 (47%) occurred among U.S. civilian children, 101 (44%) occurred among children of persons categorized as having a foreign resident status at the time their malaria infection was acquired, and 23 (10%) occurred among children of unknown resident status. Of the 108 cases among U.S. civilian children, four (4%) were aged <24 months, 10 (9%) were aged 2–4 years, 54 (50%) were aged 5–12 years, and 40 (37%) were aged 13–17 years. Seventy-six (75%) of the cases among U.S. civilian children for whom country of exposure was known were attributable to travel to Africa. Among the 83 U.S. civilian children for whom reason for travel was known, 69 (83%) were visiting friends and relatives, 10 (12%) were travelling for educational purposes, two (2%) were travelling for missionary work, and two were either tourists or specified as other. Of the 85 children for whom chemoprophylaxis information was known, 26 (31%) were reported as having taken chemoprophylaxis, of whom 16 (62%) had taken an appropriate regimen; however, only five (31%) of these 16 patients reported adherence.

Hospitalization

Information on hospitalization was reported for 80% (n = 1,352) of cases. Among those persons, at least 56% (n = 946) were hospitalized. The majority of those cases were *P. falciparum* (n = 664 [70%]), of which 130 (20%) were considered severe. The second largest proportion of cases was identified as *P. vivax* (10%) infections. The majority of *P. vivax* cases were uncomplicated malaria infections; however, 11% (n = 19) were severe.

Treatment in Uncomplicated Imported Malaria Cases

Information on treatment medicines for malaria infection in imported cases was available for 1,254 (74%) cases. Of these, 1,086 (87%) were classified as uncomplicated, including 701 (65%) *P. falciparum*, 251 (23%) *P. vivax*, 31 (3%) *P. malariae*, 26 (2%) *P. ovale*, 11 (1%) mixed cases, and 66 (6%) in which species type was unknown or unreported. The CDC Guidelines for Treatment of Malaria in the United States (*10*), herein referred to as the CDC Guidelines for Treatment, was used to determine whether the medicines listed for treatment were appropriate.

Of the total 1,086 patients with uncomplicated cases, the majority (945 [87%]) were treated appropriately according to the CDC Guidelines for Treatment (*10*) and 141 (13%) patients received inappropriate treatment. This represents a significant increase (64%) in patients with uncomplicated disease being treated appropriately compared with 2009. Among the patients who were treated appropriately, 133 (14%) indicated taking other antimalarial drugs in addition to those recommended by CDC guidelines. Because the CDC surveillance report form does not record the sequence of treatment events, it is difficult to understand and characterize the intended purpose of additional antimalarial treatment drugs. Therefore, for the purpose of this report, these 133 patients were considered to be treated appropriately. Among the 141 inappropriately treated patients, 18 (13%) had received the recommended chemoprophylaxis but subsequently had inappropriately received the same drug for treatment. Antimalarial drugs used for treatment should differ from the drugs received for chemoprophylaxis because of the potential for toxicity and reduced efficacy.

Adequacy of treatment also varied by species. For the 701 *P. falciparum* cases, 605 (86%) patients were treated appropriately according to the CDC Guidelines for Treatment, of which 78 (13%) received additional antimalarial drugs. Additionally, among the 701 *P. falciparum* cases, 96 (14%) patients were treated with an inappropriate treatment regimen, including 12 pregnant patients. Among the 31 *P. malariae* cases,

29 (93%) patients were treated appropriately according to CDC guidelines, of whom seven (24%) received other antimalarial drugs in addition to those recommended by CDC. Only two (7%) patients were treated with an inappropriate treatment regimen, and one was treated with the same drug that was used for chemoprophylaxis.

Among the 251 patients with *P. vivax* for whom treatment information was reported, 227 (90%) patients were treated with an appropriate antimalarial drug to address their acute infection, of which 34 (15%) received other antimalarial drugs in addition to those recommended by CDC. Twenty-four (10%) patients did not receive an appropriate treatment for their acute infection and 133 (53%) received primaquine for relapse prevention. Among the 26 patients with *P. ovale* for whom treatment information was reported, 23 (88%) patients were treated with an appropriate antimalarial drug to address their acute infection, of whom three (13%) received other antimalarial drugs in addition to those recommended by CDC. Three (12%) patients did not receive an appropriate treatment for their acute infection and 11 (42%) received primaquine for relapse prevention. Among the 11 mixed cases for whom treatment information was reported, eight (73%) patients were treated appropriately according to CDC guidelines; however, two received other antimalarial drugs in addition to the CDC-recommended regimens. Of the eight mixed cases that included at least one relapsing species, only one patient received primaquine.

According to the CDC Guidelines for Treatment, when species is unknown a treatment regimen for a *P. falciparum* infection should be used to presumptively treat cases. Among the 66 cases in which species was unknown, 53 (80%) patients were treated appropriately according to CDC guidelines, of whom nine (17%) received other antimalarial drugs in addition to those recommended by CDC. Thirteen (20%) patients received an inappropriate treatment regimen.

Severe Malaria

Among the 1,691 reported cases, 176 (10%) were classified as severe malaria, of which nine were fatal. The majority of severe cases (87%) occurred in persons aged ≥18 years, and 13% occurred in children aged <18 years, two (9%) of whom were aged <3 years. Where information on prophylaxis was known (n = 154), 38 (25%) persons reported taking a recommended chemoprophylaxis; however, only eight reported adherence to the drug regimen, including four who used mefloquine, two who took doxycycline, and two who took atovaquone/proguanil. Although some patients had multiple clinical complications associated with an infection, the largest proportion of patients experienced renal failure (32%) and cerebral malaria (27%), unlike in 2009, when the largest proportion of patients experienced severe anemia followed by renal failure (7). Among the 176 severe cases, 73 (41%) patients were treated with quinidine and 57 (32%) were treated with an oral antimalarial drug. Thirty-nine (22%) patients were treated with intravenous (IV) artesunate provided by CDC through an investigational new drug protocol. Patients diagnosed with uncomplicated malaria can be effectively treated with oral antimalarial drugs. However, patients who are considered to have severe disease should be treated aggressively with parenteral antimalarial therapy (*10*).

Similar to 2009 findings, no significant association was found between age, resident status, prophylaxis use, and severe malaria. Among the 167 cases in patients with known resident status, 80% were U.S. residents. The predominant species among the severe cases was *P. falciparum* (82%), which is similar to 2009 (86%).

Among patients for whom reason for travel was known, 53% of the severe cases were in VFR travelers (comparable with 2009), of whom 53% specified acquisition from West Africa, and 93% of cases were identified as *P. falciparum* infections, similar to 2009. In addition, a significant increase occurred in the number of severe cases that were acquired in Haiti, a country where virtually all of the malaria that occurs is caused by *P. falciparum*.

Similar to 2009, a significant association was found between missionary travelers and severe malaria in 2010. However, unlike 2009, a significant association was also noted between business travelers and severe malaria. Among business travelers, 30% (15 of 50) developed severe disease, compared with 16% (161 of 1,033) of U.S. civilians traveling for other purposes.

Malaria During Pregnancy

A total of 41 cases of malaria were reported among pregnant women in 2010, representing 7% of cases among all women (n = 608). The number of pregnant women with malaria increased significantly from 14 cases in 2008 (*11*); however, no significant differences were noted among pregnant women compared with the number of cases among all women in terms of species type, reason for travel, or region of infection acquisition. Of the 41 cases among pregnant women, eight (20%) cases were severe. Twenty-two (54%) cases occurred among U.S. civilians, of whom 18 (82%) reported travel to Africa. Among the 18 U.S. civilian pregnant women with known reason for travel, 83% reported visiting friends and relatives. Of the 22 cases of malaria reported among U.S. civilian pregnant women, four reported taking malaria chemoprophylaxis; however, only two reported adherence to the drug regimen. Among the 19 cases for which species type was

known, all were diagnosed with *P. falciparum* infection, including two who presented with severe malaria. No information was available on the birth outcomes of the pregnant women.

Selected Malaria Case Reports

Fatal Cases

Case 1. A man aged 54 years with a history of HIV infection, Kaposi's sarcoma, and hypertension traveled to Ghana. He did not take malaria chemoprophylaxis. Two days after returning, he had onset of fever and chills, and sought medical attention but did not receive a diagnosis or treatment. Five days later, he was found to have decreased alertness and was taken to the emergency department where he received a diagnosis of *P. falciparum* cerebral malaria (25% parasitemia) and hypertensive crisis (systolic blood pressure [SBP] 222). At the time of admission, he had a mild metabolic acidosis and normal renal function. He was admitted to the intensive care unit (ICU), intubated for airway protection, mechanically ventilated, and treated with IV quinidine and labetolol. Later that day, the patient became profoundly hypotensive (SBP 50), necessitating the addition of norepinephrine. Quinidine was discontinued, and the patient received IV artesunate instead. The following morning, he developed acute renal failure (peak blood urea nitrogen: 200, creatinine: 8.4) and elevated transaminases (AST peak: 2383) as a result of his severe hypotensive episode. That evening, he experienced cardiac arrest but was resuscitated. His parasitemia had decreased to 6.8% by hospital day 2 and <1% on day 3. His electroencephalogram (EEG) demonstrated no brain activity, supportive measures were withdrawn, and he died 8 days after onset of symptoms.

Case 2. A man aged 31years with a history of scleroderma had a febrile illness approximately 1 month after returning from a 2-week trip to Ghana. Five days after onset of illness, he was found to be confused with decreased consciousness. He was taken to the hospital emergency department where he received a diagnosis of cerebral malaria (*P. falciparum*) with a parasitemia of 7.5%. He was admitted to the ICU and treated with IV artesunate, his parasitemia resolved, and he became afebrile. However, he experienced complications including pneumothorax from mechanical ventilation (treated with a chest tube), enterococcal bacteremia, subclavaian vein thrombosis, a severe Raynaud's phenomenon with necrosis in his fingertips, renal failure, and nosocomial pneumonia. After a prolonged stay in the ICU, he experienced a cardiac arrest and was resuscitated. An EEG revealed minimal cortical activity. Comfort measures were instituted, and he died 21 days after onset of symptoms.

Case 3. A man aged 72 years with a history of noninsulin–dependent diabetes mellitus and coronary artery disease had recently traveled to Sierra Leone. He had initiated mefloquine chemoprophylaxis but discontinued taking it during the trip and switched to a locally obtained oral artemisinin product for malaria prevention. Approximately 2 weeks after returning, he reported the onset of fatigue. The following morning he was found comatose at home and was transported to the emergency department, where he was diagnosed with cerebral *P. falciparum* malaria complicated by ARDS, renal failure, acidosis, and hypotension. He was admitted to the ICU, treated with IV quinidine, and he received an exchange transfusion. He developed quinidine toxicity (QRS widening and QTc prolongation), and quinidine was discontinued and treatment with artesunate began. He had a cardiac arrest and died 5 days after onset of symptoms.

Case 4. A man aged 31 years with no notable medical history traveled to Ghana. He did not take malaria chemoprophylaxis. He became acutely ill with fever and confusion while on the flight back from Africa; the flight was diverted to a closer destination in the United States to facilitate his rapid access to medical care. On arrival in the hospital emergency department, he was comatose with lactic acidosis, jaundice, thrombocytopenia, rhabdomyolysis, and acute renal failure. A malaria smear revealed *P. falciparum* with 14% parasitemia. The patient was immediately treated with IV quinidine and doxycycline and he was admitted to the ICU. He developed refractory hypotension, and quinidine was discontinued and treatment with IV artesunate began. Despite an appropriate decrease in his parasitemia, he remained comatose and continued to have renal failure associated with hyperkalemia, which was difficult to manage despite dialysis. Magnetic resonance imaging of the head revealed cerebral edema with herniation of the brainstem. He had a cardiac arrest and, despite attempts to resuscitate him, died 4 days after admission to the hospital.

Case 5. A man aged 31 years, originally from Guyana, with no notable medical history, visited Guyana and then returned to the United States. He had onset of symptoms approximately 1 week after returning. Four days after onset of symptoms (fever, chills, and headache), he sought medical evaluation and was admitted to the hospital for evaluation of his febrile illness. The following day, he received a diagnosis of *P. falciparum* malaria (13% parasitemia) and he was transferred to the ICU and treated with IV quinidine and doxycycline. Later that day, he was found to be lethargic. CDC was contacted, and IV artesunate was provided. His neurologic symptoms continued to worsen, and a computed tomography (CT) scan of the head revealed cerebral edema with herniation of the brainstem.

Supportive measures were withdrawn, and the patient died 6 days after onset of symptoms.

Case 6. A man aged 58 years who was in Uganda as a missionary had not been taking malaria chemoprophylaxis. Nine days after returning to the United States, he developed malaise and nausea. Two days later he was noted to be confused and was taken to the emergency department, where he was diagnosed with severe *P. falciparum* infection (26% parasitemia), renal failure, and metabolic acidosis. He received treatment in the ICU with IV quinidine and clindamycin. A CT scan revealed cerebral edema. He developed respiratory failure, was intubated and received mechanical ventilation, dialysis, and an exchange transfusion. Medical interventions were unsuccessful, and he died 3 days after onset of symptoms.

Case 7. A woman aged 56 years traveled to Ghana for 3 weeks. She did not take malaria chemoprophylaxis. She had onset of symptoms (fever, chills, nausea, and fatigue) 1 week after returning to the United States and sought medical attention. She did not receive malaria diagnostic testing and was prescribed oral metronidazole and trimethoprim-sulfamethoxazole. Her symptoms progressed and 11 days later she went to an emergency department, where she was diagnosed with severe malaria (*P. falciparum* infection with 31% parasitemia) associated with renal failure, pancytopenia, and jaundice. She was admitted to the ICU, treated with IV quinidine gluconate and doxycycline, and given an exchange transfusion. She also developed ARDS and required intubation and mechanical ventilation. Four days after admission, and 15 days after onset of symptoms, she experienced a cardiac arrest and died.

Case 8. A man aged 50 years with a history of coronary artery disease had traveled to Nigeria for business. He started feeling ill 2 days after returning to the United States. Four days later he was found unresponsive. He was transported to the emergency department, where personnel determined that he was asystolic and attempted resuscitation, but the patient died. Premortem laboratory tests revealed that he was infected with *P. falciparum* (>25% parasitemia).

Case 9. A man aged 60 years, originally from Nigeria, returned to the United States after a 3-week trip to Nigeria. He took sulfadoxine/pyrimethamine for malaria prophylaxis. After 5 days in Nigeria, he developed a severe diarrheal illness, was seen by local physicians, and was given a broad-spectrum antibiotic. His diarrheal illness resolved over a period of 5–10 days. Subsequently, he developed a high-grade fever, weakness, and fatigue and was taken to a local hospital, where he was empirically diagnosed with malaria and treated with a 3-day course of an unknown medication. Despite treatment, his symptoms persisted. He then returned to the United States and went directly to an emergency department, and was admitted to the hospital. He received a diagnosis of acute myelogenous leukemia (white cell count: 300,000, with 95% blasts), *Enterococcus faecalis* and *Escherichia coli* bacteremia, and *P. falciparum* malaria (parasitemia 0.1–0.5%). His malaria was treated with oral doxycycline and atovaquone/proguanil, and he received induction chemotherapy for leukemia. He developed respiratory failure, requiring intubation and mechanical ventilation, and also developed refractory hypotension. He died 4 days after onset of symptoms.

Transfusion Transmitted Infection

Case 1. A woman aged 55 years was hospitalized in November 2010 for cardiac surgery, where she received multiple transfused blood products (8 units of leukoreduced red blood cells, 4 units of fresh frozen plasma, a double platelet pheresis, and 10 units of cryoprecipitate). One month later, she was hospitalized again for febrile illness, which was confirmed by blood smear and PCR as *P. falciparum* infection. She had not recently traveled to a malaria endemic area. She was successfully treated for malaria. In conjunction with public health authorities, 18 of the 23 blood donors were identified, reinterviewed, and verified to have met the Food and Drug Administration (FDA) donor eligibility criteria at the time of blood donation. The implicated donor was a man aged 21 years who had been born in Russia but had been living in Benin, West Africa, for 17 years before immigrating to the United States. He had not traveled internationally during the 4 years before donation. Blood samples obtained from the implicated donor 6–8 weeks after donation were negative for malaria by blood smear and an RDT (BinaxNOW); however, the blood was positive for malaria antibodies by serology and PCR was positive for *P. falciparum* DNA. *P. falciparum* DNA fragment length polymorphism analysis confirmed that the donor and recipient parasite samples were an exact match.

Cryptic Cases

Two cases reported in 2010 were categorized as cryptic malaria because epidemiologic investigations did not identify a plausible mode of acquisition.

Case 1. A Ghanaian-American female aged 17 years, born in the United States, was hospitalized, treated, and recovered from a *P. falciparum* malaria infection in New York City in December 2010. The child's mother said that her daughter had not traveled outside the United States within the last 4 years, had not received blood transfusions, did not use IV drugs, did not have occupational exposure to blood products, and had no history of malaria. Because of unfavorable environmental conditions, local malaria transmission in the northeastern region of the United States during the winter season was an

unlikely source of her infection. However, the New York City Department of Health and Mental Hygiene reviewed their vector-control data to determine whether the explanation of local transmission could be supported and found no data to support local transmission in the area where the patient lived. In the last attempt to discover the source of her infection, the public health authorities contacted the Ghana Embassy to verify her travel history. However, the embassy replied that information could not be disclosed to the public health authorities despite the circumstances. The origin of the infection remains undetermined.

Case 2. In November 2010, a woman aged 31 years sought treatment at a hospital emergency department for fever, severe headaches, nausea, vomiting, and malaise. She was admitted to the ICU for severe hyponatremia, thrombocytopenia, tachycardia, borderline splenomegaly, and epistaxis. Both the hospital and CDC confirmed a *P. falciparum* severe malaria infection with approximately 10% parasitemia. She was treated with oral quinine, clindamycin, and oral doxycycline, and recovered successfully. Probable routes of transmission were investigated. The patient stated that she had not traveled outside of the United States during the preceding 2 years and had no history of malaria. In 2008, she traveled to Nicaragua and stated that she had received malaria chemoprophylaxis at the time of her trip. She reported no history of blood transfusion or IV drug use. Mosquito trappings conducted around her home in Florida revealed no *Plasmodium*-infected mosquitoes, and no additional malaria cases in close contacts or persons residing in the area near her home. The origin of the infection remains undetermined.

Discussion

The number of malaria cases reported in the United States in 2010 was the largest since 1980 (N = 1,864) (*12*), representing a 14% increase from 2009 (*7*) and a 30% increase from 2008 (*13*). These notable increases appear to be similar to those being reported in other parts of the world. For example, in the United Kingdom, 1,761 malaria cases were reported in 2010, an 18% increase from 2009 and a 29% increase from 2008 (*13*). The majority of the U.S. cases were acquired in sub-Saharan Africa, which is also similar to the data reported by the United Kingdom. Despite the apparent progress in reducing the number of malaria cases in areas that are endemic for malaria (*14*), international travel appears to be growing steadily and use of appropriate prevention measures by travelers is still inadequate. The World Tourism Organization estimates that there were 1 billion international travelers in 2010, with notable increases in travel to Africa and South Asia (*14*). As international travel increases, prevention messages and health communication strategies become even more important for protecting the traveling community from communicable diseases. Prevention messages directed toward Africa-bound travelers, particularly those whose destination is West Africa, should be emphasized in early spring, accompanied with a reminder in late fall through early winter. Malaria prevention messages directed toward Asia-bound travelers, specifically those bound for India, should be intensified in late spring. Travelers should be informed of the risk for malaria and strongly encouraged to use protective measures, including chemoprophylaxis. Imported malaria has the potential to reintroduce malaria into regions where the disease is not endemic and environmental conditions are present that can support the lifecycle of the parasite including the presence of an appropriate *Anopheles* vector.

Of the 1,688 imported cases, 192 (11%) patients did not have information available regarding residential status and 209 (12%) did not have information regarding travel history. This is a substantial improvement compared with 2009, when residential status and travel history were unknown for 40% and 33% of patients, respectively. Additionally, a notable increase (46%) occurred in the number of cases with species information compared with 2009. This represents substantial progress in the completeness of reporting of surveillance data to CDC compared with previous years. An increase in completeness of reporting improves the accuracy with which the data reflect trends in malaria surveillance in the United States. Local and state health departments, health-care providers, and other health personnel should exercise continued vigilance in reporting complete information for malaria cases. Improving the number of cases with complete reporting is a reflection of collaboration among CDC and the local and state health departments and health-care providers. Specifically, if certain variables are not reported (e.g., species, residence, and country of acquisition), efforts are made to obtain complete information for comprehensive analysis.

In the Caribbean region, the endemic transmission of malaria ended in the mid-1960s, except in the island of Hispaniola, which includes the countries of the Dominican Republic and Haiti (*15*). An increase in the numbers of malaria cases acquired in Haiti had already been noted prior to the January 2010 earthquake (*7*). This increase continued throughout 2010 and is likely the result of both increased transmission in Haiti as well as increased volume of travel between the United States and Haiti (*16,17*). In 2010, the majority of the 132 U.S. resident cases imported from Haiti were identified as VFR travelers; however, 28 persons were identified as U.S. relief aid workers. Among these U.S. resident cases, 113 reported no

prophylaxis use and only four reported adherence to a CDC-recommended drug regimen. Among the four persons who had reported adherence to antimalarial drugs, two reported taking chloroquine for malaria prevention. Recent reports of emerging molecular markers of chloroquine drug resistance in Haiti (*18,19*) indicate a need for increased vigilance for evidence of clinical chloroquine chemoprophylaxis or treatment failure. So far, this has not been demonstrated, and chloroquine remains an effective choice for chemoprophylaxis and treatment of malaria acquired in Haiti. Health-care providers should contact CDC to assist with the evaluation of possible chloroquine failures identified among U.S. travelers or immigrants to the United States from Haiti.

Among the 26 severe cases that were acquired in Haiti, at least 18 were among U.S. civilians. The significant increase in the number of cases in 2010 compared with previous years might be a result of the increased number of travelers to Haiti or an increase in malaria risk because of poor health infrastructure and inadequate shelter after the earthquake. Although the cause of the increase in cases is not known, failure to take chemoprophylaxis is the most common risk factor for acquisition of malaria among travelers to malarious areas. Messages must be conveyed to VFR travelers that they are still at substantial risk for malaria despite beliefs that partial immunity offers protection from disease (*20*). Relief aid workers must be counseled to take preventive measures, including use of malaria chemoprophylaxis when traveling to Haiti.

Airline crews based in the United States comprise a very small proportion of cases that are reported in this annual surveillance summary; however, the number of reported cases might increase as direct daily flights between Africa (particularly to West Africa) and the United States increase (*21*). Nine cases were identified among airline crew members, including four employed by the same airline company who had traveled to Accra, Ghana, during the same time period. Airline staff members stayed in Ghana up to 3.5 days; spending time outdoors near the swimming pool, nonair–conditioned restaurants, and other outdoor locations in the evening and at nighttime. The company provides antimalarial medications free of charge to all airline staffers. None had taken chemoprophylaxis for malaria prevention. Because of this particular cluster of cases, the airline company initiated a knowledge, attitude, and practices survey to learn more about the knowledge and perceptions of malaria among their staff. Although survey participants demonstrated satisfactory knowledge about malaria transmission and protective measures, overall perception of malaria as an occupational risk was low (CDC, unpublished data, 2011). Organizations and companies with employees who must travel to malaria-endemic regions should incorporate employee education and training on the use of and compliance with measures to prevent malaria infection. Additionally, companies should review and remove any potential barriers that hinder employees from accessing necessary prevention medicines or information.

In 2010, a total of 46 cases were reported among military personnel, a notable increase from 2009 (n = 18). In previous years, cases among patients who were traveling for military duty to regions where malaria is endemic were only reported to CDC by local and state health departments and private health clinicians. However, through a recent partnership with the AFHSC, additional cases occurring among military personnel are being identified that might have not been identified previously by local or state health departments or private health-care providers. This improves opportunities to monitor and survey trends or changes (e.g., in geographical transmission and prophylaxis or treatment failures among the deployed military population).

Forty-one cases were reported among pregnant women in 2010, approximately a threefold increase in the number of malaria cases reported among pregnant women since 2008 (*11*). This continued increase of malaria during pregnancy poses a high risk for both maternal and perinatal morbidity and mortality (*22*). Moreover, eight pregnant women were classified as having severe malaria cases, four times as many compared with 2009. Pregnant women should be counseled to avoid travel to malarious areas. If deferral of travel is unavoidable, pregnant women should be informed that the risks for malaria greatly outweigh those associated with prophylaxis, and chemoprophylaxis should be used (*23*). For pregnant women who travel to areas with chloroquine-sensitive *P. falciparum* malaria, chloroquine can be taken for malaria chemoprophylaxis. For pregnant women who travel to areas with chloroquine-resistant *P. falciparum*, mefloquine should be recommended for chemoprophylaxis. Additional information for pregnant travelers is available at http://wwwnc.cdc.gov/travel/yellowbook/2012/chapter-8-advising-travelers-with-specific-needs/pregnant-travelers.htm. Mefloquine was changed from a pregnancy category C to a category B medication in 2011 by FDA. Mefloquine is considered safe for pregnant women during all trimesters of pregnancy.

Nine fatal cases were reported in 2010, more than double the number of fatal cases compared with 2009 (7). All were *P. falciparum* infections, of which seven were acquired in West Africa. Several patients had delayed seeking treatment after onset of symptoms, including one who received a delayed diagnosis 11 days after presenting to the hospital. The

differential diagnosis of fever in a person who has returned from travel should always include malaria as one of the primary possibilities. Signs and symptoms of malaria often are nonspecific but typically include fever. 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. Health-care providers should ask all febrile patients for a travel history. Any delay in the diagnosis and treatment of malaria can result in complications, regardless of the effectiveness of the treatment regimen.

The choice of a specific antimalarial treatment regimen should be based on several key factors, including the probable geographic origin of the parasite, the *Plasmodium* species, parasite density, and the patient's clinical status (*24*). Of the 1,691 cases, species confirmation was provided by CDC for 7% of cases. Microscopy is still considered the best method for the immediate diagnosis of malaria; however, PCR testing is particularly valuable for species confirmation and should be used in all instances when species cannot be determined by microscopy or to evaluate for mixed infections. CDC can provide assistance to reference laboratories or health departments that do not perform PCR testing. Increasing the proportion of cases with accurate diagnosis will improve the understanding of malaria epidemiology as presented in annual malaria surveillance summaries.

Patients with suspected or confirmed malaria who are severely ill should be treated aggressively with parenteral antimalarial therapy regardless of the species of malaria seen on the blood smear. Quinidine gluconate continues to be recommended for parenteral malaria therapy. However, this medication is no longer available in many hospital formularies. Because parenteral quinidine gluconate is potentially cardiotoxic, it should be administered in an intensive care setting with continuous cardiac and frequent blood pressure monitoring. An alternative to quinidine gluconate, IV artesunate is also highly effective in the treatment of severe malaria and is available as an investigational new drug (IND) through CDC. Artesunate is stocked at nine sites around the United States and can be rapidly shipped at no cost to clinicians, when needed. Certain guidelines and eligibility requirements must be met to enroll a patient in the treatment protocol. Physicians who administer the drug to patients must notify CDC of any adverse event after administration and comply with the IND protocol (*25*). To enroll a patient with severe malaria in this treatment protocol, health-care providers should telephone the CDC Malaria Hotline at 770-488-7788 or toll-free at 855-856-4713, Monday–Friday, 9 a.m.– 5 p.m., Eastern time. At other times, callers should telephone 770-488-7100 and ask to speak with a CDC Malaria Branch clinician.

Travelers and health-care providers are encouraged to use CDC resources on malaria prevention and treatment, and contact the CDC Malaria Branch for assistance with diagnostic or case management needs.

Detailed recommendations for preventing malaria are available to the general public 24 hours a day online at http://wwwnc.cdc.gov/travel/yellowbook/2010/chapter-2/malaria.aspx#990. Additional information on malaria prevention recommendations is also available through the online CDC malaria map application at http://www.cdc.gov/malaria/map. The application is an interactive map that provides information on malaria throughout the world. Users can search or browse countries, cities, and place names and get information about malaria in that particular location and see recommended malaria prophylaxis for that area. Also, CDC biannually publishes recommendations in *Health Information for International Travel* (commonly referred to as *The Yellow Book*), which is available and updated on the CDC Travelers' Health website at http://wwwnc.cdc.gov/travel/default.aspx; the publication is also available for purchase from Oxford University Press, Inc., at http://www.oup.com/us or telephone 1-800-451-7556 (Table 7).

Health-care providers should be familiar with prevention, recognition, and treatment of malaria, and are encouraged to consult appropriate sources for malaria prevention and treatment recommendations (Table 7). A recent evaluation of malaria diagnosis capabilities among U.S. laboratories demonstrated that although malaria diagnostic testing services were available to the majority of U.S. laboratories surveyed, very few were in compliance with all of the current guidelines (*26*). To maintain and improve malaria and other parasitic disease diagnosis capabilities in the United States, CDC's Parasitology Diagnostic Service team conducts training courses several times per year (www.dpd.cdc.gov/dpdx/HTML/Aboutdpdx.htm). Physicians seeking assistance with the diagnosis (including telediagnosis) or treatment of patients with suspected or confirmed malaria should call CDC's Malaria Hotline at telephone 770-488-7788 or toll-free at 855-856-4713 during regular business hours or CDC's Emergency Operations Center at telephone 770-488-7100 during evenings, weekends, and holidays (ask to page the person on call for the Malaria Branch), or access CDC's Internet site at http://www.cdc.gov/malaria/diagnosis_treatment/index.html. These resources are intended for use by health-care providers only.

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 Traveler's Health Internet site (includes online access to *Health Information for International Travel*)	24 hours/day	http://wwwnc.cdc.gov/travel
	Health Information for International Travel (*The Yellow Book*)	Order from Oxford University Press, Inc. Order Fulfillment 198 Madison Avenue, New York, NY 10016-4314	800-451-7556 or http://www.oup.com/us
	CDC Malaria Map Application	24 hours/day	http://www.cdc.gov/malaria/map
Diagnosis	CDC's Division of Parasitic Diseases and Malaria diagnostic internet site (DPDx)	24 hours/day	http://www.dpd.cdc.gov/dpdx
	CDC's Division of Parasitic Diseases and Malaria diagnostic CD-ROM (DPDx)	Order by electronic mail from CDC Division of Parasitic Diseases and Malaria	dpdx@cdc.gov
Treatment	CDC Malaria Branch	9:00 am–5:00 pm Eastern time, Monday–Friday	770-488-7788 or toll-free 855-856-4713*
	CDC Malaria Branch	5:00 pm–9:00 am Eastern time on weekdays and all day weekends and holidays	770-488-7100* (This number is for the CDC's Emergency Operations Center. Ask staff member to page the person on call for the Malaria Branch.) http://www.cdc.gov/malaria/diagnosis_treatment/treatment.html

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

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