

Zoonoses: Dogs

Author:

Camille N Kotton, MD

Section Editor:

Jason Stout, MD

Deputy Editor:

Milana Bogorodskaya, MD

INTRODUCTION

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Pets serve valuable social roles in society [1,2]. Pets may lower blood pressure, reduce cholesterol and triglyceride levels, and lessen feelings of loneliness, while increasing opportunities for exercise, outdoor activities, and socialization [1].

In a small, randomized, controlled study of 28 patients with chronic age-related disabilities living in a nursing home, patients were randomly assigned to animal interaction ("pet therapy") compared with usual activities (control group) [3]. The "pet therapy" group patients had improved symptoms of depression and a significant decrease in blood pressure values as compared with the control patients.

Despite these benefits, pets present zoonotic risks, especially for immunocompromised hosts [4-6]. The epidemiology of dog-related zoonoses will be reviewed here. The epidemiology of pet-related zoonoses other than dogs is presented separately (see "Zoonoses: Cats" and "Zoonoses: Animals other than dogs and cats"). The clinical management of specific zoonotic diseases is discussed under the appropriate topic reviews.

DEFINITION

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A zoonosis is an animal disease that is transmissible to humans. Humans are usually an accidental host that acquire disease through close contact with an infected animal who may or may not be symptomatic.

INCIDENCE

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The American Pet Association estimates that there are approximately 56 million dog-owning households in the United States, who own a total of about 87 million dogs [7]. The most common route of infection related to dogs is through bites, especially in children. Dogs bite more than four million people a year; from 2005 to 2013, approximately 350,000 people were treated in United States hospital emergency departments for nonfatal dog bite-related injuries [8,9]. (See "Animal bites (dogs, cats, and other mammals): Evaluation and management".)

RISK FACTORS

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Health care providers should ask about pets when taking a medical history and formulating a differential diagnosis. Children are at highest risk for infection because they are more likely to have close contact with pets.

New pets can pose more of a health risk because health history and vaccination records may not be known. In addition, adult pets are generally safer than younger animals, since they are less likely to be involved in playful activities that include scratching and biting.

Increasingly, travel-associated illnesses are reported in pets. These may be seen in the setting of companion travel (eg, importation of ticks [10]) and international adoptions (eg, a case of subclinical canine melioidosis due to *Burkholderia pseudomallei* was reported in a dog adopted from Thailand [11]).

While pet dogs pose higher risk for direct zoonotic transmission via bites, licks, and transmission of antimicrobial-resistant bacteria, stray dogs are more frequently involved in environmentally transmitted diseases, particularly soil- and water-borne parasites (eg, leptospirosis) due to uncontrolled urination/defecation and lack of screening and care [12].

Many of the risks posed by pet ownership can be reduced by good hygiene after handling pets, careful pet selection, and proper pet care. (See 'Prevention' below.)

TRANSMISSION

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Dogs are responsible for transmission of an extensive array of bacterial and parasitic zoonotic pathogens (table 1A-C). Many different routes of transmission can cause infections related to pets, including:

- Contact with infectious saliva that contaminates bite wounds, skin abrasions, or mucous membranes. (See '[Saliva pathogens](#)' below.)
- Hand-to-mouth transfer of microorganisms, cysts, or oocysts (eggs) from feces of an infected animal. Transmission from feces can also occur via direct contact, when bare skin comes in contact with soil contaminated with filariform larva of different kinds of animal hookworms (cutaneous larva migrans). (See '[Stool pathogens](#)' below.)
- Insect bites when these vectors are carried into the home by pets or when bites transmit disease from an infected pet to humans. (See '[Pathogens from insects](#)' below.)
- Aerosol exposure from body fluids (eg, respiratory secretions, placenta). (See '[Aerosolized infected body fluids](#)' below.)
- Contact with water or soil contaminated with urine containing a pathogen. (See '[Urine pathogens](#)' below.)

Saliva pathogens

— Saliva from an infected dog can be transmitted when the human is bitten or the saliva comes in contact with a skin abrasion or mucous membrane, such as through licking. Dog bites are the most common type of animal bite with most bites occurring in children. Bacterial contamination occurs with all animal bites, however, only 5 percent of dog bites develop local infection [13].

Rabies

— In resource-limited countries, dogs account for 90 percent or more of rabies cases transmitted to humans. In contrast, in the United States, where vaccination rates among dogs are currently high [14] (although with growing vaccine hesitancy [15]), wild animals are the major animal reservoirs [16]. While the likelihood of domestic animal (eg, dog and cat) rabies is small in the United States, it varies by region. In the continental United States, rabies among dogs is most often reported along the United States-Mexico border. However, sporadic cases do occur outside of this area, particularly in areas with enzootic wildlife rabies. (See "[Rabies immune globulin and vaccine](#)".)

Rabies is a fatal disease in dogs, which can have several phases including the prodromal, furious, and paralytic stages. Dogs are most often infected by the bite of another infected animal. Rabies is transmitted to humans by contaminated saliva through a bite, scratch, or lick of a rabid animal.

Human rabies is rare in the United States, with only 17 cases reported between 2015 and 2024, two of which related to exposure during foreign travel [17-20]. Rabies should be considered in the differential diagnosis of patients presenting with acute progressive encephalitis, regardless of a history of an animal bite. Because of the nonspecific early symptoms, other more common infectious and noninfectious disorders (eg, encephalitis caused by arboviruses or enterovirus and Guillain-Barré syndrome or vasculitis) should be ruled out (algorithm 1). (See "[Clinical manifestations and diagnosis of rabies](#)".)

Pasteurella

— *Pasteurella* spp can serve as either commensals or pathogens in animals and can be found in the oral cavity of dogs (*P. canis* and *P. dagmatis*). *Pasteurella* spp have been the most frequent isolates from both dog and cat bites (50 and 75 percent, respectively) [21]. The infection rate from penetrating dog bites ranges from 2 to 10 percent.

Pasteurella spp can cause soft-tissue infections following animal bites or scratches, as well as surgical site infections caused by licks from pet dogs [22]. Rarely, *Pasteurella* can cause pneumonia, septic arthritis, and osteomyelitis [23]. Urinary tract infections have also been reported [24,25]. (See "[Pasteurella infections](#)".)

Capnocytophaga

— *Capnocytophaga* was first isolated in 1976 from the blood and CSF of a patient who had been bitten by a dog [26]. *Capnocytophaga canimorsus* (formerly US Centers for Disease Control and Prevention group DF-2) is a fastidious, gram-negative rod that forms part of the normal oral flora of dogs and cats. (See "[Capnocytophaga](#)".)

Both *C. canimorsus* and *C. cynodegmi* can cause human infection following a dog or cat bite or scratch, although sometimes no such trauma is remembered by the patient [27,28]. *C. canimorsus* can cause fulminant sepsis and meningitis, particularly in asplenic patients or alcoholics [29]. The mortality rate for *C. canimorsus* septicemia is 30 to 36 percent but mortality due to meningitis is much lower (5 percent) [29-32]. (See "[Clinical features, evaluation, and management of fever in patients with impaired splenic function](#)".)

C. cynodegmi bite wound infections are a less severe infection that is usually restricted to skin and soft tissues, although a case report described the death of a splenectomized woman who received a dog bite and developed *C. cynodegmi* sepsis and meningitis [33].

Stool pathogens

— Common zoonotic pathogens causing canine gastroenteritis include *Salmonella*, *Campylobacter*, *Cryptosporidium*, and *Giardia*; dogs with diarrhea should have a stool specimen examined for these pathogens [34]. In addition, numerous parasitic diseases can be transmitted from dogs to humans through feces, including toxocariasis, cutaneous larva migrans (*Ancylostoma caninum* and *A. braziliense*), echinococcosis, and dipylidiasis. *Clostridioides difficile* has also been isolated from dogs with diarrhea, sometimes with resistance to metronidazole [35,36].

Salmonella

— In 1999 and 2000, four outbreaks of gastrointestinal illness due to multi-drug resistant *Salmonella enterica* serotype Typhimurium were reported in employees, clients, and animals from three veterinary clinics and one animal shelter; more than 45 persons and pets became ill [37].

Salmonella can also be transmitted from handling contaminated pet food [38] and through animal-derived pet treats, including pig ear treats, beef steak patty dog treats, and pet treats of seafood origin [39]. To prevent such infection, individuals should wash their hands with soap and water after handling dry pet foods, especially before handling food for humans. In contrast, the manufacturing process for canned pet food should eliminate bacterial contamination.

Salmonella spp infections transmitted to humans usually result in a mild, self-limiting gastroenteritis. However, severe invasive illness, such as septicemia or meningitis, can occur especially in infants, pregnant people, and immunocompromised persons. (See "[Nontyphoidal *Salmonella*: Gastrointestinal infection and asymptomatic carriage](#)".)

Campylobacter

— *Campylobacter* enteritis most commonly presents in people with prominent abdominal pain and profuse diarrhea that is often bloody (see "[Campylobacter jejuni infection](#)"). The organism is known to be present in dog populations. For example, in Barbados, a surveillance study identified *Campylobacter* species in fecal specimens from 61 of 130 pet dogs (47 percent) [40].

Direct zoonotic transmission of *Campylobacter* to humans from dogs and puppies has been documented, including at least one case of neonatal sepsis [41-43]. In the United States, extensively drug-resistant *Campylobacter jejuni* infections have repeatedly occurred in humans exposed to pet store puppies. Clinicians should inquire about puppy exposure when treating patients with *Campylobacter* infection, especially when routine antibiotics fail to resolve the infection [44].

Giardia lamblia

— *Giardia lamblia* (also known as *G. duodenalis* or *G. intestinalis*) is a flagellated protozoan parasite and one of the most common gastrointestinal parasites in the United States. The spectrum of clinical disease in humans includes asymptomatic infection, self-limited acute giardiasis, and chronic infection. (See "[Giardiasis: Epidemiology, clinical manifestations, and diagnosis](#)", section on 'Clinical manifestations'.)

Transmission of infectious *Giardia* cysts to humans may occur via three routes: waterborne, foodborne, or fecal-oral transmission. The greatest risk of zoonotic transmission appears to be from pets, especially dogs and cats. A surveillance study of *G. intestinalis* isolates obtained from children with diarrhea and their dogs found that genotype A was associated with zoonotic transmission [45-47]. However, zoonotic transmission may be infrequent, since human disease peaks in the United States in August and September, whereas canine disease does not seem to have any significant or distinct seasonality [48].

Toxocara canis

— *Toxocara canis* (dog roundworm) causes visceral larva migrans and ocular larva migrans in humans. These roundworms live in the small intestine of the dog in the adult stage, where eggs are passed in the feces. Up to 15 percent of healthy older dogs actively excrete *T. canis* [49]. In endemic areas, empiric treatment of dogs lowered the rate of *Toxocara* infection in children [50]. The World Health Organization (WHO) and United States Centers for Disease Control and Prevention (CDC) have classified toxocariasis amongst the top six parasitic infections of priority to public health [51].

Human infections are caused by ingestion of eggs from contaminated hands, soil, or fomites and are usually asymptomatic to mild and accompanied by a persistent eosinophilia. The larvae penetrate the intestinal wall but are unable to complete their life cycle and produce eosinophilic granulomas in host tissues. Infection produces a syndrome in humans termed visceral larva migrans or toxocariasis. Toxocariasis can present in five distinct forms: the classical visceral larva migrans, common toxocariasis, ocular toxocariasis, covert (subclinical) toxocariasis, and cerebral toxocariasis or neurotoxocariasis [51]. (See "[Toxocariasis: Visceral and ocular larva migrans](#)".)

Systemic toxocariasis most often affects children aged one to four. Clinical manifestations include eosinophilia, rash, fever, cough, weight loss, hepatosplenomegaly, pulmonary infiltrates, seizures, and behavior disorders. Ocular larva migrans often presents in older children with a unilateral reduction in vision or strabismus and often with retinal involvement but without the systemic symptoms or eosinophilia seen in visceral disease.

Ancylostoma caninum

— The hookworm *A. caninum* and *A. braziliense* are the etiologic agents of cutaneous larva migrans. The eggs are shed in the feces of infected dogs or cats. In the United States, the dog hookworm, *A. caninum*, is a commonly occurring parasite.

Humans (and pets) are infected when bare skin comes in contact with soil contaminated with the larvae. The second-stage larvae are able to penetrate the intact skin of humans and the footpads of dogs and cats. (See "[Hookworm-related cutaneous larva migrans](#)", section on 'Life cycle'.)

A pruritic, erythematous papule develops initially at the site of each larval entry. Two to three days later, and at times weeks later, severely pruritic, elevated, serpiginous, reddish-brown lesions appear, as the larvae migrate at a rate of several millimeters per day (picture 1) [52]. (See "[Hookworm-related cutaneous larva migrans](#)", section on 'Cutaneous disease'.)

Echinococcus

— Dogs and other carnivorous mammals are the definitive hosts for the tapeworm, *Echinococcus granulosus* (figure 1). The adult tapeworm inhabits the small intestine of the dog and can produce eggs that are expelled in the feces contaminating the environment. The eggs are infective to humans. Once ingested, they enter the portal circulation and spread to the liver and other tissues, where they are either destroyed or form hydatid cysts. The cysts slowly enlarge over years, due to the multiplying larvae inside. The most common sites of infection in humans are the liver, lung, bone, kidney, and brain. (See "[Echinococcosis: Clinical manifestations and diagnosis](#)".)

The epidemiology of *E. granulosus* is described elsewhere. (See "[Epidemiology and control of echinococcosis](#)".)

Dipylidium caninum

— The dog tapeworm, *Dipylidium caninum*, commonly infects domestic cats and dogs and may also accidentally infect humans. Fleas usually serve as the intermediate hosts and contain cysticercoids. If a human (usually a child) ingests cysticercoids (larva), an adult tapeworm can develop in the intestine.

This infection is usually asymptomatic. However, abdominal pain, diarrhea, pruritus ani, and urticaria can develop. In addition, parents may notice the passage of proglottids (eg, body segments of the adult tapeworm, which have a complete set of reproductive organs) that resemble cucumber seeds in their children's stool. (See

"Tapeworm infections".)

Drug-resistant bacteria

— Antibiotic-resistant organisms, such as *Escherichia coli*, can be passed from pets to owners. Transmission of resistant organisms will likely increase as more pets are exposed to cephalosporins, fluoroquinolones, and other antibiotics that exert positive selective pressure for resistant bacteria [53-55].

A survey of dogs in Ontario, Canada found that the average frequency of fecal carriage of extended-spectrum cephalosporin-resistant Enterobacteriaceae (CRE) in healthy dogs was 26.5 percent [56]. This is much higher than in humans, and suggests the transfer of resistant bacteria from food and other possible exposures. (See "[Extended-spectrum beta-lactamases](#)" and "[Carbapenem-resistant *E. coli*, *K. pneumoniae*, and other Enterobacterales \(CRE\)](#)".)

Aerosolized infected body fluids

Bordetella bronchiseptica

— *Bordetella bronchiseptica* causes kennel cough in dogs, snuffles in rabbits, and atrophic rhinitis in piglets. Healthy dogs may harbor small numbers of this bacterium in their oropharynx.

Although rare, human infection with *B. bronchiseptica* has been documented in both healthy and immunocompromised individuals [57-63]. Of nine HIV patients from whom *B. bronchiseptica* was isolated, respiratory illnesses ranged from mild upper respiratory tract infections to pneumonia [61]. Two of these persons had household contact with dogs prior to their illness. (See "[Pertussis infection: Epidemiology, microbiology, and pathogenesis](#)".)

Coxiella burnetii

— *Coxiella burnetii*, the etiologic agent of Q fever, is a worldwide zoonosis. The most commonly identified sources of human infection are farm animals, but dogs may also rarely serve as a source [64,65]. Infected mammals shed *C. burnetii* in urine, feces, milk, and birth products. Infected dogs may be asymptomatic, but infection may cause abortion or rapid death of newborn pups [64]. A serologic survey on 429 dogs from France found 9.8 percent were positive for *C. burnetii*; dogs that had contact with sheep were more likely to be seropositive [66].

In humans, exposure results from inhalation of contaminated aerosols from parturient fluids of infected mammals, which can be present in the environment, on the coats of newborn animals, or from the placenta.

Clinical signs of Q fever are often extremely mild or absent. Patients may be asymptomatic or can present acutely with one of three clinical presentations:

- A self-limited flu-like illness
- Pneumonia
- Hepatitis

A case report describes the development of *C. burnetii* pneumonia in all three members of one family, 8 to 12 days after exposure to an infected parturient dog [64].

Chronic infection most commonly involves the heart as endocarditis.

Further information regarding Q fever can be found separately [67,68]. (See "[Q fever: Epidemiology, microbiology, and diagnostic tests](#)" and "[Acute Q fever in nonpregnant patients](#)" and "[Chronic Q fever, including endocarditis](#)" and "[Q fever in pregnancy](#)".)

Brucella

— *Brucella canis* infection in dogs appears to have a worldwide distribution, but human infections with *B. canis* are either uncommon or uncommonly recognized [69]. Instead, the *Brucella* spp that are frequently associated with human brucellosis are *B. melitensis*, *B. suis*, and *B. abortus*. Humans may become infected when they are exposed to body fluids from a *B. canis*-infected dog. Most cases of human transmission from dogs are in farm settings [70-72].

Human brucellosis is a well-documented cause of fever of unknown origin with varied and nonspecific symptoms. (See "[Brucellosis: Epidemiology, microbiology, clinical manifestations, and diagnosis](#)".)

Urine pathogens

Leptospirosis

— *Leptospira interrogans*, the etiologic agent of human leptospirosis, infects a variety of both wild and domestic mammals, including dogs. Animals can be asymptomatic or develop clinical infection, which can be fatal. Although clinical leptospirosis is common in dogs, it appears to be rare in cats [73]. Mortality in dogs is estimated at 10 percent. Vaccination of dogs has been successful in preventing disease in endemic regions [74].

Transmission to humans occurs by contact with water or soil contaminated with the urine of infected animals (predominantly rats). A case-control study of an outbreak in rural Nicaragua in 1995 found that owning an infected dog was a significant risk factor for disease (matched odds ratio 23.4, 95% CI 3.6 to infinity) [75]. Outbreaks of dog-associated leptospirosis have also been reported in the United States [76]. However, in one study that evaluated the risk of transmission during an outbreak in Arizona, there was a low risk of transmission with good infection control measures [77].

Leptospirosis may manifest as a subclinical illness followed by seroconversion, a self-limited systemic infection, or a severe, potentially fatal illness accompanied by multiorgan failure.

Leptospirosis usually presents with the abrupt onset of fever, rigors, myalgias, and headache, after an incubation period of 2 to 26 days (average 10 days). Many patients have an associated nonproductive cough, nausea, vomiting, and diarrhea. (See "[Leptospirosis: Epidemiology, microbiology, clinical manifestations, and diagnosis](#)".)

Skin pathogens

Methicillin-resistant *Staphylococcus aureus*

— Methicillin-resistant *Staphylococcus aureus* (MRSA) appears to be an emerging veterinary and zoonotic pathogen. Transmission between infected or colonized domestic pets and humans in veterinary clinics and in households has been documented, both animal-to-human and human-to-animal [78]. The transmission may be clinically relevant as illustrated by a case of recurrent MRSA infection in a patient with diabetes and his wife. Further recurrence of MRSA infection was prevented only after successful eradication of asymptomatic nasal carriage of MRSA in the family's pet dog. In a study where *S. aureus* was isolated concurrently from humans and their pet dogs or cats, 50 percent of cases showed strains that were indistinguishable from human and pets, suggesting significant rates of transmission [79]. (See "[Methicillin-resistant *Staphylococcus aureus* \(MRSA\) in adults: Epidemiology and microbiology](#)" and "[Methicillin-resistant *Staphylococcus aureus* \(MRSA\) in children: Epidemiology and clinical spectrum](#)" and "[Methicillin-resistant *Staphylococcus aureus* \(MRSA\) in adults: Prevention and control](#)" and "[Methicillin-resistant *Staphylococcus aureus* \(MRSA\) in children: Prevention and control](#)".)

Staphylococcus pseudintermedius

— *S. pseudintermedius* is a common colonizer and pathogen of companion animals, including dogs [80]. Human infection with *S. pseudintermedius* is increasingly being recognized, especially in those who are immunocompromised. Clinical manifestations include skin and soft tissue infections after a dog bite, respiratory infections, and bacteremia. The organism shares pathogenic similarities with *S. aureus*, expressing several analogous virulence factors and toxins.

Pathogens from insects

— Dogs can transport ticks or fleas, which may subsequently bite a human host and transmit infectious diseases. In addition, an infected dog may act as a reservoir of disease borne by other arthropod vectors, such as mosquitoes and sand flies, which in turn, after feeding on the dog, can transmit disease to humans by their bite.

Ticks can carry many diseases, including *Borrelia burgdorferi* (Lyme disease), *Ehrlichia* (ehrlichiosis), *Babesia microti* (babesiosis), *Francisella tularensis* (tularemia), and *Rickettsia rickettsii* (Rocky Mountain Spotted Fever [RMSF]). Fleas carried by dogs can bite a human host and transmit plague. Mosquitoes can transmit dirofilariasis, and sand flies can transmit leishmaniasis from the dog reservoir to humans by their bite.

Lyme disease

— Lyme disease is caused by *B. burgdorferi*, which is spread by the bite of infected *Ixodes* ticks ([picture 2](#)). Approximately 95 percent of cases of Lyme disease in the United State are reported from twelve states: Massachusetts, Connecticut, Maine, New Hampshire, Rhode Island, New York, New Jersey, Pennsylvania, Delaware, Maryland, Michigan, and Wisconsin.

In highly endemic areas, dog owners should inspect their pets regularly for ticks, as tick collars have a variable efficacy. Owners should inspect their dogs for ticks for two reasons. First, dogs can develop Lyme disease, which presents as sudden onset lameness with a swollen, warm, and tender joint. Second, dogs may carry ticks indoors, and if these ticks carry *B. burgdorferi* and attach to a human, they may then transmit Lyme disease to the pet's human family. Dogs have served as sentinel animals to assess the prevalence of *B. burgdorferi* infection in ticks in a region [81-83].

Human Lyme disease is a multisystem inflammatory disease. One of the first clinical manifestations is the classic erythema migrans skin lesion ([picture 3](#)) that occurs in up to 90 percent of patients. (See "[Clinical manifestations of Lyme disease in adults](#)".)

Rocky Mountain spotted fever

— The principal vectors of RMSF in the eastern and south-central United States are *Dermacentor variabilis* (the American dog tick) ([picture 4](#)) and *Dermacentor andersoni* (the Rocky Mountain wood tick) ([picture 5](#)) in the mountain states west of the Mississippi River. Dogs develop rickettsial infection when bitten by infected ticks and then act as a source of infection for other feeding ticks. These ticks may then transmit infection to other dogs or their owners. Dogs may serve as environmental sentinels for establishing the geographic prevalence of foci of spotted fever [84].

Numerous case reports have described concurrent RMSF in dogs and their owners [85-88]. In an outbreak of RMSF with a newly identified vector (the common brown dog tick, *Rhipicephalus sanguineus*) ([picture 6](#)) in Arizona, all patients with confirmed disease had contact with tick-infected dogs [89]. In the United States, RMSF is most prevalent in the southeastern and south central states, with North Carolina and Arkansas accounting for the largest numbers of cases.

The clinical spectrum of human infection with *R. rickettsii* ranges from mild to fulminant. In the early phases of illness, most patients have nonspecific signs and symptoms such as fever, headache that is often severe, malaise, myalgias, arthralgias, and nausea with or without vomiting. Most patients develop a rash between the third and fifth days of illness ([picture 7](#)). (See "[Epidemiology, clinical manifestations, and diagnosis of Rocky Mountain spotted fever](#)".)

Ehrlichiosis

— The two most important human ehrlichial diseases are human monocytic ehrlichiosis (HME), which is caused by *E. chaffeensis*, and human granulocytic anaplasmosis (HGA), which is caused by *Anaplasma phagocytophilum*. The principle vector of *E. chaffeensis* is thought to be the Lone Star tick (*Amblyomma americanum*, whose primary host is deer) ([picture 8](#)). *A. phagocytophilum*, in contrast, may be transmitted by *Ixodes scapularis* ([picture 2](#)), the tick that is also the vector of Lyme disease and babesiosis (see below). Most cases of HME have occurred in the southeastern, south-central, and mid-Atlantic regions of the United States. States with the highest incidence of HGA during 2001 to 2002 were Rhode Island, Minnesota, Connecticut, New York, and Maryland. HGA is also reported in Western Europe.

E. ewingii, the agent of canine granulocytic ehrlichiosis can cause disease in humans. Cases of *E. ewingii* human disease with clinical features of illness similar to HME were reported from Missouri [90]. Polymerase chain reaction distinguished the *E. ewingii* organism from *E. chaffeensis*; morulae were observed in granulocytes in two of the patients; and one patient's dogs displayed a similar serologic reaction as the patient, suggesting zoonotic transmission.

The clinical manifestations of HME and HGA are variable. Most patients are febrile with nonspecific symptoms including malaise, myalgia, headache, and chills. (See "[Human ehrlichiosis and anaplasmosis](#)".)

Babesiosis

— Babesiosis is a tick-borne illness caused by malaria-like parasites that infect red blood cells and result in hemolysis. Human disease is most commonly due to *B. microti* (United States) or *Babesia divergens* (Europe). The vector for babesiosis is the Ixodid tick, the same vector as Lyme disease and anaplasmosis. Babesiosis occurs predominantly on the northeast coast of the United States.

The clinical manifestations of disease can range from asymptomatic infection to severe hemolytic anemia associated with jaundice, hemoglobinuria, renal failure, and death. (See "[Babesiosis: Microbiology, epidemiology, and pathogenesis](#)".)

Tularemia

— Tularemia is a zoonosis caused by the gram-negative bacterium, *Francisella tularensis*. Humans are accidental hosts following contact with infected animals or vectors. In the United States, tularemia has been reported from 49 states, but the majority of cases occur in the south central states, mainly Arkansas, Missouri, and Oklahoma. Infection by vectors (ticks in the Rocky Mountain region and eastward and biting flies in California, Nevada, and Utah) is the most common way the disease is transmitted in the United States. Occupational exposure with subsequent ulceroglandular tularemia was reported in a veterinarian after lancing an abscess in a dog [91]. (See "[Tularemia: Microbiology, epidemiology, and pathogenesis](#)".)

Patients infected with *F. tularensis* present with the abrupt onset of fever, chills, headache, and malaise, after an incubation period of 2 to 10 days. (See "[Tularemia: Clinical manifestations, diagnosis, treatment, and prevention](#)".)

Yersinia pestis

— *Y. pestis* is the etiologic agent of plague. Dogs are susceptible to infection and may be a significant sentinel animal. Dogs become infected after being bitten by rodents' fleas and have a brief and self-limited illness [5]. They can carry the infected fleas, which can spread disease to humans through a flea bite. Foci of plague are present on most continents other than Australia. In the United States, plague is endemic in all of the western states and has extended north and east over the years. Ninety percent of human cases in the United States have occurred in four states: Arizona, California, Colorado, and New Mexico. (See "[Epidemiology, microbiology and pathogenesis of plague \(Yersinia pestis infection\)](#)".)

Three generally recognized clinical syndromes are associated with plague: bubonic, septicemic, and pneumonic. (See "[Clinical manifestations, diagnosis, and treatment of plague \(Yersinia pestis infection\)](#)".)

Dirofilaria immitis (Dog heartworm)

— *D. immitis*, the dog heartworm, is a vascular parasite, with the adult worm residing in the pulmonary artery and right ventricle [92]. Most dogs are asymptomatic, but some animals may have exercise intolerance, hemoptysis, or signs of right ventricular outflow obstruction. Dirofilariasis is particularly common in the Mediterranean region but has been reported from many different countries, including the United States. (See "[Miscellaneous nematodes](#)".)

The organism is transmitted to humans by *Aedes*, *Anopheles*, *Culex*, or *Myzorrhynchus* mosquitoes, which ingest blood-containing microfilaria from affected dogs. Two clinical syndromes of dirofilariasis occur in humans: pulmonary and cutaneous infection. Cutaneous infection occurs when the larva die after inoculation into the subcutaneous tissue and cause an urticarial eruption. If a larva survives and reaches the heart, it dies and forms an embolus, which travels to the lungs resulting in focal pneumonitis followed by granuloma formation. The pulmonary emboli are identified as a "coin lesion" on radiograph and the diagnosis of dirofilariasis is made when the lesion, appearing to be a neoplasm, is removed surgically. There are no medications used to treat humans. (See "[Miscellaneous nematodes](#)".)

Leishmania

— Leishmaniasis is caused by a heterogeneous group of protozoan parasites belonging to the genus *Leishmania*. Humans and mammals, including the dog, are reservoirs for the disease. Female sand flies transmit the disease from an infected mammal to humans. In a serologic surveillance study in Iran, dog ownership and dog density in a village was a significant risk factor for seropositivity in children [93]. In a comprehensive epidemiologic survey in Israel, while dog disease was somewhat common, human disease was not and was often with different *Leishmania* strains, suggesting that dogs may not be an important vector [94]. Attempts at dog culling to reduce the incidence of leishmaniasis have not been successful [95].

Most human infections with *Leishmania* are asymptomatic. However, when they cause symptoms, *Leishmania* spp can cause cutaneous, mucocutaneous, or visceral disease. (See "[Cutaneous leishmaniasis: Clinical manifestations and diagnosis](#)" and "[Visceral leishmaniasis: Clinical manifestations and diagnosis](#)".)

Bartonella

— *Bartonella* causes a variety of different diseases (eg, adenopathy, skin lesions, endocarditis) and can be transmitted via tick and flea bites. Although *Bartonella* can infect dogs, cats serve as the major reservoir for *Bartonella* infections in humans. Direct transmission of *Bartonella* from dogs to humans has not been documented [96], despite findings that *Bartonella* can be found in dog saliva [97]. (See "[Biology of Bartonella species](#)".)

Dogs can be infected with several different species of *Bartonella*, including *B. vinsonii* (subspecies *berkhoffii*), *B. henselae*, *B. clarridgeiae*, *B. washoensis*, *B. elizabethae*, and *B. quintana* [98]. Stray or wild dogs and those in the tropics are most likely to be infected [98,99]. When infected, dogs are more likely to be symptomatic than cats.

Contaminated dog food

Salmonella

— There are numerous reports of humans becoming ill from *Salmonella* species (eg, *Salmonella* Schwarzengrund and *Salmonella* Infantis) contaminating dry pet food [38,100,101]. Transmission likely occurs from direct handling of food and from contact with the animal's excrement. Pet owners should not handle or store pet food in

areas where human food is prepared or consumed. In addition, they should wash their hands with warm water and soap for at least 20 seconds after handling pet food/treats or cleaning up after pets.

PREVENTION

General precautions

— Although dogs have been implicated in transmission of zoonoses to their owners, risk of transmission from contact with dogs is low and may be further reduced by simple precautions.

- Dogs should be seen by a veterinarian on a regular basis, treated promptly for diarrhea, vaccinated for rabies, and treated to prevent heartworm disease (*Dirofilaria immitis*).
- Effective flea control requires treatment of affected dogs, their environment, and other animals they contact.
- Dogs should be fed high-quality commercial food and should not eat raw meat or eggs. A Dutch study that analyzed 35 commercial, frozen, raw meat-based diets from various different brands found significant rates of *E. coli* serotype O157:H7, extended-spectrum beta-lactamase-producing *E. coli*, *Listeria monocytogenes*, and *Salmonella* species in the food [102].
- Dogs should not be allowed to eat garbage, feces, or hunt [6], and should not be allowed to drink nonpotable water (eg, surface water or toilet water).
- Stray dogs that have been free roaming should be carefully examined and tested by a veterinarian before residing in human homes, as they may have had significant exposures to major zoonotic illness such as dirofilariosis, caused by *Dirofilaria immitis* (the giant kidney worm), as was recently reported in Brazil in a community dog park [103].
- Dogs should be inspected for ticks regularly.
- Owners should wash their hands following contact with or cleaning up dog feces.

Immunocompromised hosts

— Groups at high risk for serious infection from pets include:

- Persons with waning immunity (eg, older adults)
- Children less than five years old
- Pregnant women
- Immunocompromised patients (either due to disease or treatment), some with more advanced AIDS [104] and those without a functioning spleen

Numerous reports exist of the transmission of zoonoses to humans during and after solid organ and hematopoietic stem cell transplantation [105]. Most zoonoses present as a primary infection in the post-transplant period; immunocompromised patients are more likely to experience significant morbidity and mortality from these infections.

To avoid infections, people at higher risk should take particular precautions with any animal contact. In addition to thorough and frequent hand washing, these precautions might include avoiding contact with animals and their environment (eg, pens, bedding, and manure). For children, risk for exposure might be reduced if they are closely supervised by adults, carried by adults in animal areas, or have animal contact only over a barrier. These measures discourage animals from jumping on or nuzzling children and minimize contact with feces and soiled bedding.

The United States Public Health Service and the Infectious Diseases Society of America have issued formal recommendation for people living with HIV who desire pet contact [34,106]. The guidelines specify:

- When obtaining a new pet, people living with HIV or their caregivers should avoid animals aged <6 months or stray animals [107].
- People living with HIV should be cautious when obtaining a pet from pet-breeding facilities, pet stores, and animal shelters, because of highly variable hygienic and sanitary conditions. Stray animals should be avoided.
- People living with HIV should avoid contact with any animal that has diarrhea. Pet owners living with HIV should seek veterinary care for animals with diarrheal illness, and a fecal sample from such animals should be examined for *Cryptosporidium*, *Salmonella*, and *Campylobacter*.
- People living with HIV should always wash their hands after handling pets, especially before eating, and should avoid contact with pets' feces.
- People living with HIV should avoid contact with reptiles (eg, snakes, lizards, iguanas, and turtles) as well as chicks and ducklings (and their uncooked eggs) because of the risk for salmonellosis.
- Gloves should be used during aquarium cleaning to reduce the risk for infection with *Mycobacterium marinum*.
- Contact with exotic pets (eg, nonhuman primates) should be avoided.
- Such precautions are especially important for people living with HIV who are not receiving effective ART.

Public health education

— A survey of knowledge and perceptions of dog-associated zoonoses uncovered a major lack of knowledge in the general public. While 98 percent of respondents had heard of rabies and knew that acquisition was possible from a dog, only 59 percent of respondents were aware that exposure to rabies without treatment could lead to death, and only 54 percent of respondents knew that worms could be transmitted from dogs to people [108]. As roughly half of households in the USA have a dog, better public knowledge about zoonoses might mitigate transmission.

SOCIETY GUIDELINE LINKS

— Links to society and government-sponsored guidelines from selected countries and regions around the world are provided separately. (See "[Society guideline links: Rabies](#)".)

INFORMATION FOR PATIENTS

— UpToDate offers two types of patient education materials, "The Basics" and "Beyond the Basics." The Basics patient education pieces are written in plain language, at the 5th to 6th grade reading level, and they answer the four or five key questions a patient might have about a given condition. These articles are best for patients who want a general overview and who prefer short, easy-to-read materials. Beyond the Basics patient education pieces are longer, more sophisticated, and more detailed. These articles are written at the 10th to 12th grade reading level and are best for patients who want in-depth information and are comfortable with some medical jargon.

Here are the patient education articles that are relevant to this topic. We encourage you to print or e-mail these topics to your patients. (You can also locate patient education articles on a variety of subjects by searching on "patient info" and the keyword(s) of interest.)

- Beyond the Basics topics (see "[Patient education: Animal and human bites \(Beyond the Basics\)](#)")

SUMMARY AND RECOMMENDATIONS

- **Definition** – A zoonosis is an animal disease that is transmissible to humans. Humans are usually an accidental host that acquire disease through close contact with an infected animal, who may or may not be symptomatic. (See '[Definition](#)' above.)
- **Risk factors** – Children are at highest risk for infection because they are more likely to have close contact with pets. (See '[Risk factors](#)' above.)
- **Transmission** – Dogs are responsible for transmission of an extensive array of bacterial and parasitic zoonotic pathogens. The route of transmission can be through the feces, urine, saliva (eg, bites or contaminated scratches), or respiratory secretions of the animal, or by the dog or cat acting as a vehicle and source of tick or flea exposure or reservoir for vector borne disease. (See '[Transmission](#)' above.)
- **Prevention** – Although dogs have been implicated in transmission of zoonoses to their owners, risk of transmission from contact with dogs is low and may be further reduced by simple precautions. (See '[Prevention](#)' above.)

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