

Zoonoses

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Diseases that are transmitted from animals to humans. Zoonotic agents are found among all major categories of microbes, including bacteria, fungi, parasites, and viruses (see **table**). Although anyone can acquire a zoonotic infection, young children, older adults, and immunocompromised individuals are most at risk. Currently, there are large numbers of people that are considered immunocompromised (for example, people receiving chemotherapy or those infected with agents such as HIV).

Animals can also serve as reservoirs for zoonotic agents; that is, they are a source of the microorganism that allows transmission to the human population. Domesticated animals can often serve as a bridge for zoonotic agents that are commonly found in feral animal populations. However, sometimes animals serve only as indicators that an organism is present in the environment. In these cases, they become infected from contaminated soil, water, or air, as do humans. Additionally, there are diseases, called anthroponoses, that are transmitted from humans to animals.

Nervous system infections

Important zoonotic agents that can invade the nervous system in humans include *Toxoplasma gondii* and *Cryptococcus neoformans*.

Toxoplasma. Thirty to forty percent of adult humans in the United States are seropositive for *T. gondii*. Feline species are the only definitive hosts for the organism. Cats harbor sexual stages of the parasite in their gastrointestinal tract and shed infectious oocysts in their stool. The organism has been found in all areas of the world, in over 200 species of birds, and in many species of warm-blooded animals, which act as intermediate hosts. Intermediate hosts become infected by ingesting sporulated oocysts from cats. Humans can contract the disease by ingesting inadequately cooked meat of the intermediate hosts with infectious bradyzoites and tachyzoites, or by ingesting oocysts from soil contaminated with cat feces. In one European study, more than 50% of the meat of pigs and sheep carried toxoplasmosis. Humans can be infected by ingesting any source of meat with *Toxoplasma*, but lamb, mutton, and pork are most commonly infected. *See also:* TOXOPLASMIDA.

Cryptococcus. *Cryptococcus neoformans* is an important pathogen in immunosuppressed patients and occurs commonly as a premonitory sign of acquired immune deficiency syndrome (AIDS), where it causes severe life-threatening meningitis. *Cryptococcus* is taken up by the human host via the respiratory tract. The organism has been found in soil, plants, bird feces, raw milk, and fruit juices, and from the oral cavity, gastrointestinal tract,

Some significant zoonoses*	
Disease by category	Etiologic agent
BACTERIAL AND RICKETTSIAL	
Anthrax	<i>Bacillus anthracis</i>
<i>Bordetella bronchiseptica</i> pneumonia	<i>Bordetella bronchiseptica</i>
Brucellosis	<i>Brucella</i> sp.
Capnocytophaga	<i>Capnocytophaga canimorsus</i>
Cat-scratch, bacillary angiomatosis	<i>Bartonella henselae</i> , <i>Afipia felis</i>
Chlamydiosis/psittacosis	<i>Chlamydia psittaci</i>
Ehrlichiosis (monocytic and granulocytic)	<i>Ehrlichia chaffeensis</i> , <i>E. phagocytophilia</i>
Enteric disease	<i>Campylobacter jejuni</i> , <i>Clostridium perfringens</i> , <i>Escherichia coli</i> , <i>Salmonella</i> sp., <i>Vibrio parahemolyticus</i> , <i>Yersinia enterocolitica</i>
Leptospirosis	<i>Leptospira</i> sp.
Listeriosis	<i>Listeria monocytogenes</i>
Lyme disease	<i>Borrelia burgdorferi</i>
Murine typhus	<i>Rickettsia typhi</i>
Pasteurellosis	<i>Pasteurella multocida</i>
Plague	<i>Yersinia pestis</i>
Q fever	<i>Coxiella burnetti</i>
Rat bite fever	<i>Streptobacillus moniliformis</i>
Rickettsialpox	<i>Rickettsia akari</i>
Rhodococcosis	<i>Rhodococcus equi</i>
Scrub typhus	<i>Oriente tsutsugamushi</i>
Spotted fever, Rocky Mountain	<i>Rickettsia rickettsii</i>
Tuberculosis	<i>Mycobacterium bovis</i>
Tularemia	<i>Francisella tularensis</i>
MYCOTIC	
Cryptococcosis	<i>Cryptococcus neoformans</i>
Dermatomycosis or ringworm	<i>Microsporum canis</i> , <i>Trichophyton mentagrophytes</i>
PARASITIC	
African trypanosomiasis, sleeping sickness	<i>Trypanosoma brucei rhodesiense</i>
American trypanosomiasis or Chagas' disease	<i>Trypanosoma cruzi</i>
Anisakiasis	<i>Anisakis</i> sp., <i>Pseudoterranova</i> sp., <i>Contraeacum</i> sp.
Balantidiasis	<i>Balantidium coli</i>
Clonorchiasis	<i>Clonorchis sinensis</i>
Coccidioides	<i>Cryptosporidium parvum</i> , <i>Sarcocystis</i> sp.
Cutaneous larva migrans	<i>Ancylostoma caninum</i> , <i>A. braziliense</i>
Diphyllobothriasis or fish tapeworm	<i>Diphyllobothrium latum</i>
Dipylidiasis or dog tapeworm	<i>Dipylidium caninum</i>
Dirofilariasis	<i>Dirofilaria immitis</i> , <i>D. repens</i>
Giardiasis	<i>Giardia lamblia</i>
Hydatid disease or echinococcosis	<i>Echinococcus</i> sp.
Paragonimiasis	<i>Paragonimus westermani</i>
Leishmaniasis	<i>Leishmania donovani</i> , <i>L. tropica</i> , and other species
Piroplasmosis, babesiosis	<i>Babesia microti</i> and other species
Taeniasis or cysticercosis	<i>Taenia saginatum</i> , <i>T. solium</i>
Toxoplasmosis	<i>Toxoplasma gondii</i>
Trichinosis	<i>Trichinella</i> sp.
Visceral larva migrans	<i>Toxocara canis</i> , <i>T. cati</i> , <i>Baylisascaris procyonis</i>
VIRAL	
Ebola and Marburg hemorrhagic fevers	RNA Filovirus
Encephalitis (La Cross, California)	RNA Bunyavirus
Equine encephalitis (Eastern, Western, Venezuelan)	RNA Togavirus
Hantavirus pulmonary syndrome	RNA Hantavirus
Hemorrhagic fevers: Argentine, Bolivian, Brazilian, Venezuelan	RNA Arenaviruses
Hemorrhagic fever: Crimean-Congo	RNA Nairovirus
Hemorrhagic fever: renal	RNA Hantavirus
Hendra or Nipah diseases	RNA Paramyxovirus
Hepatitis	RNA Hepatitis A
Herpes B	DNA Herpes simplex
Lassa fever	RNA Arenaviruses
Lymphocytic choriomeningitis	RNA Arenaviruses
Monkey pox, cowpox	DNA Orthopoxviruses
Orf	DNA Parapoxvirus
Rabies	RNA Lyssaviruses
Rift Valley fever	RNA Bunyavirus
Vesicular stomatitis	RNA Vesiculovirus
West Nile fever	RNA Flavivirus

*Based on data from William T. Hubbert, Ann Marie Nelson, and Brett Saladin.

and skin of healthy humans. It is commonly found in pigeon roosts and in soil contaminated by pigeon feces, and has been isolated from droppings of other bird species. *Cryptococcus neoformans* has an ecological relationship with pigeons in that it selectively assimilates creatinine in pigeon urine. See also: ACQUIRED IMMUNE DEFICIENCY SYNDROME (AIDS).

Respiratory tract infections

Bordetella bronchiseptica is a secondary bacterial invader that occurs commonly in the respiratory tracts of dogs, cats, and pigs, and less commonly in horses. It complicates the management of viral respiratory disease in the dog, and has been associated with clinical signs of fever, anorexia, coughing, and nasal discharge. Immunocompromised patients should avoid exposing themselves and their dogs to environments with sources of *B. bronchiseptica* such as dog shows, kennels, or other settings where dogs are housed closely together.

Gastrointestinal tract infections

Agents causing primary gastrointestinal disease that have been documented to be transmitted to humans from an animal source include *Salmonella*, *Campylobacter*, *Mycobacteria*, *Cryptosporidia*, and *Giardia*. Agents that have been implicated as zoonotic agents include *Entamoeba*, *Isospora*, and *Microsporidia*.

Salmonella. *Salmonella* is an important pathogen in humans. Salmonellosis is a major communicable disease problem in humans in the United States, with the infection rate estimated as high as 2 million cases per year. Poultry and beef products are the largest sources of nontyphoid *Salmonella* in the United States. Contaminated animals and animal products are a major source of *Salmonella* for humans. The most common source is from contaminated foods. Strict hygiene in food preparation is needed to avoid contaminating cold-served food products (such as salads and coleslaw) with raw meat. It is estimated that the rate of infection of *Salmonella* in domestic animals is 1–3%. Transmission of antibiotic-resistant *S. typhimurium* to humans has been reported due to contact with sick calves shedding the organism.

Salmonellosis is frequently diagnosed in dogs and cats, and these animals can also be a source of infection for humans. Confining dogs and cats in the house as much as possible minimizes their contact with fecal material of other animals. Avoidance of feeding pets raw meat prevents their contracting the disease from a well-known source of salmonellosis. Animals with diarrhea should be presented promptly to a veterinarian for diagnosis. Treatment of pets with salmonellosis is usually not recommended unless clinical signs of bacteremia are evident, because treatment may prolong the period of shedding of the organism. Pets should not be returned to the household of immunosuppressed individuals until two fecal cultures taken 24 h apart are negative for *Salmonella*. It is important that these fecal cultures be taken after any antibiotic treatment has ended. *Salmonella* is also carried commonly by cold-blooded animals. *See also:* SALMONELLOSIS.

Campylobacter. *Campylobacter* is another common gastrointestinal and blood infection that can be transmitted from animals to humans. *Campylobacter* is a significant cause of enteritis in humans all over the world; it has been targeted as one of four bacterial pathogens for elimination from human food supplies by United States agencies. *Campylobacter jejuni* is the most important species, although other species of *Campylobacter* can cause diarrhea in humans. Transmission of *C. jejuni* to humans occurs commonly from contaminated food and water. Meat products, especially poultry, are frequently contaminated with this bacteria. *Campylobacter jejuni* is

found generally in water sources, where it can live for several weeks at low temperature. Many animals, including cattle, sheep, swine, fowl, dogs, and cats, excrete *Campylobacter* species. Household pets, especially kittens and puppies, frequently shed these organisms, with an incidence of isolation of *Campylobacter* in feces as high as 35–42%. To prevent infection with *Campylobacter*, people should cook meat products thoroughly and wash cooking utensils well. Immunocompromised individuals should be aware of the risks of owning or coming in contact with puppies and kittens and their excreta. Animals with diarrhea should be presented promptly to their veterinarian, and a fecal sample should be taken for testing for *Campylobacter*. If *Campylobacter* species are isolated from dogs or cats, treatment with erythromycin is recommended to eliminate shedding of the organism in feces.

Cryptosporidium. *Cryptosporidium* is a protozoan parasite that is only 1–6 micrometers in size. It lacks host specificity and infects the gastrointestinal tract of a wide range of mammals.

Cryptosporidium parvum is the most important species in humans and domesticated animals. It has been shown to occur naturally in mice, rabbits, guinea pigs, cats, dogs, squirrels, raccoons, horses, pigs, sheep, goats, cattle, and several species of nondomesticated ruminants. Isolates from humans have proven infective to cats, cattle, dogs, goats, mice, pigs, rats, sheep, and other humans. Transmission of *C. parvum* to humans from cats, cattle, and pigs has also been reported. *Cryptosporidium parvum* is a common cause of diarrhea in young calves who acquire the organism from their mothers and the environment; it is commonly shed in the feces of calves with no clinical signs of disease. Fecal contamination of food and water contribute to the high prevalence of cryptosporidial infection in persons residing in areas with poor sanitary conditions. Contaminated food, fomites, flies, and water are sources of infection with *Cryptosporidium*. Oocysts have proven resistant to most chemical disinfection at approved concentrations, and disinfection of drinking water by common methods is not effective.

Giardia. *Giardia* is a flagellate protozoan parasite that infects the gastrointestinal tract of many species of animals including dogs, cats, horses, pigs, cattle, sheep, goats, and many other mammals. It naturally infects humans, and is endemic in many developing countries where the prevalence in children is as high as 30%. Pets are potential sources of *Giardia* for humans. Studies in New Jersey have shown infection rates of 35% and 2.5% in stray dogs and stray cats, respectively. Other studies found high infection rates in cattle, beavers, and coyotes. Treatment for giardiasis is difficult in companion animals. Infected animals should be isolated from other animals in the household, and treated and bathed to remove cysts from the fur. Strict personal and food hygiene minimizes the risk of *Giardia* infection from human sources. *See also: GIARDIASIS.*

Parasitic diseases of animals

Some parasitic diseases of animals have zoonotic potential. The dog heartworm, *Dirofilaria immitis*, is endemic in many areas of North America and the rest of the world, requiring daily chemical prophylaxis in pet dogs during the mosquito season. Humans can be accidentally infected by *D. immitis* microfilaria-carrying mosquito vectors

due to the high prevalence of *D. immitis*, although the disease is rare. The disease in humans is often diagnosed when a solitary lung lesion or coin lesion is noted on a chest radiograph and confirmed by biopsy.

Toxocara. *Toxocara canis* and *T. cati* are round worms of the dog and cat. Humans acquire infection with these parasites by ingesting embryonated eggs shed in the feces of animals. Visceral larva migrans occurs when eggs hatch, penetrate the intestine, and migrate through body tissue. Migration can result in multiple abscesses, eosinophilic granulomas, hepatomegaly, and pneumonitis with eosinophilia. Symptoms include coughing, nausea, vomiting, and dyspnea (difficulty in breathing). Larva migrans can also affect the eyes. Ocular larva migrans causes inflammation, fibrosis, and loss of vision. The disease most often occurs in children less than 3 years of age, but can also occur in adults. The infant and toddler age group is most predisposed due to the tendency to ingest soil. Eggs of *Toxocara* are extremely resistant in soil and remain infectious for years. Routine yearly fecal exams and treatment of positive animals with anthelmintics is recommended to decrease the potential for this problem.

Ancylostoma caninum and *A. brasiliense* are hookworms of dogs and cats which rarely cause cutaneous larva migrans in humans. Hookworm eggs are shed in feces into the environment, hatch, and undergo two larval molts to produce infectious, third-stage larvae. Hookworms infect their definitive hosts by penetrating the skin. In the correct host, larvae migrate from the skin to the lungs, ascend the respiratory tree, and are swallowed to resume development in the intestine, where they mature into adult hookworms. Accidental infection of animal hookworms in humans usually occurs through larval penetration of the extremity when walking barefoot through infected soil. After skin penetration, the larvae migrate in the germinal layer of the epidermis, causing sinuous tunnels with associated itching and inflammatory response. The larvae can survive in the skin for several weeks or months. Although some human infections may be associated with pneumonitis and eosinophilia when the larvae invade the lung or other organ tissue, most cases are limited to the skin.

Echinococcus. *Echinococcus granulosus* and *E. multilocularis* are tapeworms that cause hydatid disease or echinococcosis. *Echinococcus granulosus* is a tapeworm whose life cycle involves dogs, coyotes, wolves, and dingos as the primary hosts and sheep, swine, cattle, moose, caribou, and humans as intermediate hosts. This parasite is endemic in North and South America, England, Africa, the Middle East, Australia, and New Zealand. In the United States, it occurs mainly in the western states. *Echinococcus multilocularis* is a tapeworm that cycles between dog, cat, and fox as definitive hosts, and between vole, lemming, cattle, horse, swine, and humans as intermediate hosts. *Echinococcus multilocularis* is endemic in north-central Europe, Alaska, Canada, and the central United States as far south as Illinois and Nebraska. Dogs and cats that ingest wild game and rodents can be infected with *E. multilocularis* and can be a risk to humans. Humans act as intermediate hosts for both of these parasites. Humans ingest *Echinococcus* eggs from feces of the definitive hosts, which hatch in the intestines, releasing a larval tapeworm that migrates and develops in tissues. Hydatid cysts are formed which are found in the liver, lung, nervous system, bone, spleen, kidney, and heart. Symptoms range from inapparent to severe and relate to the site of the cyst and whether it ruptures. Prevention of infection involves avoidance of contact with

fecal matter from pets and wild carnivores, good personal and food hygiene, keeping pets indoors, and routine fecal exams of pets for parasites.

Fleas. Fleas are common, difficult to eliminate, and capable of transmitting several important zoonotic diseases. However, in the United States, fleas are mostly a nuisance problem causing pruritis and hypersensitivity in animals and humans. Control of fleas must focus on the environment of the pet, such as the house and the yard. Pets may be treated for fleas weekly, but treatment must coincide with treatment of the environment.

Dipylidium caninum is a common tapeworm of dogs and cats. Cats and dogs are infected during grooming by ingesting the flea intermediate host containing an infective cysticercoid. Cysticercoids mature into adult tapeworms in the intestine of their normal host. Tapeworm eggs that are shed in the feces of an infected dog or cat are eaten by flea larvae, where they hatch and develop to the cysticercoid in the body cavity of the flea. Humans, especially children, are accidentally infected when they swallow a flea while crawling on the floor or while playing with pets.

Ticks. Animals are exposed to ticks when they roam fields and wooded lots. Ticks transmit many zoonotic diseases, including babesiosis, tick fever, rickettsial diseases, Lyme disease, Q-fever, relapsing fever, typhus, ehrlichiosis, and tularemia. Humans are exposed to ticks by similar means, but in some cases can acquire ticks from animals. Pets kept indoors are less likely to acquire ticks. Humans can use tick repellants, should check themselves for ticks after a walk in the woods, and should avoid tick-infested areas. *See also:* LYME DISEASE; RICKETTSIOSSES; TULAREMIA.

Systemic disease

Bartonella species, including *B. henselae* (formerly *Rochalimaea*), a member of the rickettsia family, have been implicated as causative agents in cat scratch disease and bacillary angiomatosis (vascular tumors of the skin, internal organs, bone marrow, and lymph nodes). In humans, cat scratch disease is characterized by persistent regional lymphadenopathy in the lymphatic drainage area of the site of a recent cat bite or cat scratch. In immunocompetent hosts, cat scratch disease tends to be a disease of children, usually self-limited and localized to regional lymph nodes. It rarely causes systemic or widespread infections. In HIV-infected hosts, the disease usually affects young adults and manifests itself as bacillary angiomatosis. Manifestation of bacillary angiomatosis includes cutaneous nodules resembling Kaposi sarcoma, encephalopathy (disease of the brain), lymphadenopathy, pneumonitis (inflammation of lung tissue), bone lesions, hepatosplenomegaly (enlargement of the liver and the spleen), and hypotension (low blood pressure) with metabolic acidosis. The disease in HIV-infected individuals is widespread, but responds to antibiotic therapy. *Bartonella henselae* is widespread in the cat population, with isolation from the blood of 41–46% of cats in studies involving household, stray, and pound cats. Since arthropods are known vectors for the transmission of rickettsias, prevention should be focused on flea control and minimizing direct transmission by cats. Specific measures include declawing of pet cats, avoiding bites or scratches from cats, and strict flea control. *See also:* BARTONELLOSIS; CAT SCRATCH DISEASE.

Pasteurella multocida is an important pathogen in animal bites and a documented life-threatening pathogen in immunocompromised patients. *Pasteurella multocida* has been found in the oropharynx of 60–90% of healthy cats and in 55% of dogs. Transmission occurs via traumatic wounds such as bites and scratches, by the respiratory route via aerosol, and by ingestion. Dissemination and septicemia (persistence and multiplication of living bacteria in the blood) have been noted in patients on chemotherapy, with cirrhosis, or with hematologic malignancy. Two cases of *P. multocida* have been documented in an HIV-infected individual. One patient undergoing peritoneal dialysis developed peritonitis, and another patient developed sinusitis and pneumonia apparently from aerosol transmission by a cat. To minimize transmission of *P. multocida*, one should avoid being bitten or scratched by pet dogs and cats. *See also:* PASTEURELLA; PASTEURELLOSIS.

There are many sources of information on zoonotic diseases, including nonprofit organizations and the United States Centers for Disease Control. Overall, the risk of contracting zoonotic diseases by susceptible individuals is likely to be small, but physicians and veterinarians can decrease this risk by educating patients on the transmission and prevention of these diseases. *See also:* ANIMAL VIRUS; MEDICAL BACTERIOLOGY; MEDICAL PARASITOLOGY.

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