

General Information

- ▶ *Salmonella* is a genus of Gram-negative, facultatively anaerobic, rod-shaped bacteria of the family Enterobacteriaceae.
- ▶ The nomenclature of the *Salmonella* genus is complex. It contains only two species, *S. enterica* and *S. bongori*, with over **2400 serotypes** between them.
 - Serotypes are identified by their somatic (O) and flagellar (H) antigens.
- ▶ There are six subspecies of *S. enterica*. The serotypes most commonly found in humans all belong to *S. enterica* subsp. *enterica*. It is therefore common to omit the species and subspecies, and **refer to different serotypes by the genus** (italicized) **and serotype** (capitalized, not italicized). Some of the most common human serotypes are *Salmonella* Enteritidis, *S. Heidelberg* and *S. Typhimurium*.
 - *Salmonella* Typhi, a very pathogenic serotype, is the cause of the typhoid fever in humans. Unlike other serotypes, *S. Typhi* is not known to infect animals and is of little to no zoonotic importance.
- ▶ *Salmonella* is an important cause of disease in humans and pets. The most common sign of illness is diarrhea. However, *Salmonella* can also be carried by humans and pets without any clinical signs at all.
- ▶ *Salmonella* Infection can spread beyond the gastrointestinal tract, resulting in severe, even life-threatening **systemic illness**, particularly in young, elderly or immunocompromised individuals and animals.
- ▶ *Salmonella* is so commonly found in reptiles that **all reptiles** should be assumed to be carriers of *Salmonella*, and handled appropriately.
- ▶ **Almost all warm- and cold-blooded animal species can carry or be infected by *Salmonella* of some kind.** Dogs and cats are often subclinical carriers of *Salmonella*, but rabbits, rodents and other small pocket pets, reptiles, birds and livestock (e.g. cattle, horses, poultry, swine) can also carry strains of the bacteria.
- ▶ The risk of transmission of *Salmonella* between animals and people can be reduced by increasing awareness of the means of transmission and some common-sense infection control measures.



Prevalence & Risk Factors

Humans

- Salmonellosis is one of the most common causes of bacterial enteric illness in humans worldwide. In Canada, approximately 6,000-12,000 cases of salmonellosis are reported yearly, but because diarrheal diseases are typically under-reported, the true incidence may be closer to hundreds of thousands of cases.
 - Most cases of salmonellosis are attributed to foodborne transmission, but outbreaks have been linked to exposure to **contaminated pet food** and pet treats, exposure to **livestock**, and exposure to **pets, particularly reptiles**.
 - Salmonellosis can affect anyone, including healthy adults. However, young, elderly or immunocompromised individuals are at higher risk of developing disease and serious complications when exposed to *Salmonella*.



Animals

- Recent studies estimate the prevalence of *Salmonella* in most clinically healthy dogs to be 1% to 4%, and <1% to 18% in clinically healthy cats. **The majority of dogs and cats with *Salmonella* show no clinical signs of infection.**
- *Salmonella* in dogs and cats appears to be more common in high-density populations such as kennels, catteries, shelters, and racetracks.
- Risk factors for *Salmonella* carriage in dogs and cats include **raw meat diets** and exposure to **livestock**. There are few published studies looking at the associations between *Salmonella* carriage and other pet management factors, such as antimicrobial use, probiotics, environmental exposures, and exposure to other animals.





- *Salmonella* in pocket pets such as mice, rats, gerbils, hamsters, and guinea pigs is likely also quite common. In 2004, hamsters were implicated in an outbreak of human salmonellosis in the USA. *Salmonella* is very commonly found in reptiles, and reptile exposure has caused multiple outbreaks of salmonellosis in humans.
- There is reasonable evidence of transmission of *Salmonella* from companion to humans in some instances, particularly from cats in animal facilities, and some household dogs have been implicated.
- Adult dogs and cats seem to be somewhat naturally resistant to clinical disease due to *Salmonella*. **Risk factors for clinical salmonellosis** that have been identified during hospital outbreaks in dogs include pre-existing disease, prolonged hospitalization, major surgery, steroid therapy, neoplasia and chemotherapy, and antimicrobial therapy.



Habitat & Environmental Survival

The primary habitat of *Salmonella* is the **intestine of humans and animals**. However, *Salmonella* is a very hardy organism, and **can potentially be found almost anywhere** – in soil, water, and animal feces in many different kinds of environments – and it can survive for long periods of time, particularly in the presence of organic matter. Nonetheless, most disinfectants, including a simple 1:10 solution of household **bleach**, can effectively kill *Salmonella* **if** all visible organic debris is removed beforehand, and adequate contact time (10-15 minutes) is allowed.

Transmission of *Salmonella*

- *Salmonella* is usually transmitted by ingestion of **contaminated water or food**, or **contamination of the hands** with fecal material which is then transferred to the mouth.
 - ▶ Contamination of food is not limited to products of animal origin. For example, fruits and vegetables which have been irrigated or fertilized with contaminated water or manure, and which are not washed with potable water or cooked prior to consumption, can also be an important source of *Salmonella*.
- Clinical disease is much less common following contact with feces from either wild or domestic animals than following foodborne transmission.
- Animals may be infected in the same manner – by consuming contaminated water or food, or ingesting the bacteria after licking or chewing a contaminated object.
- The dose of *Salmonella* required to cause disease in a particular person or animal is not well understood, and varies considerably. **The number of organisms that need to be ingested in order to cause illness depends on the virulence of the strain and the immune/health status and age of the host.**



Symptoms and Signs

Humans: Clinical signs of salmonellosis in humans can range from **none** to severe acute **diarrhea**. The infection can also spread to tissues in the body beyond the intestine, resulting in **complications** such as septicemia, focal abscesses, meningitis, osteomyelitis, reactive arthritis, or endocarditis. Immunocompromised, young or elderly individuals are at a particularly high risk for severe disease associated with *Salmonella* infection, and in some cases the **infection can be fatal**, especially in infants. In most individuals, uncomplicated intestinal infection is self-limiting, but chronic infection can occur in some cases, resulting in similar but intermittent signs over a period of months. Affected individuals, both human and animal, typically shed the organism in the feces intermittently, and can shed for prolonged periods of time (weeks), even after clinical signs resolve.

Animals: *Salmonella* infection is usually subclinical in pets, but it can be associated with acute, intermittent or chronic diarrhea in dogs and cats. Diarrhea may be bloody, and may be accompanied by fever, depression, inappetence and vomiting. Infection can also spread beyond the gastrointestinal tract, causing bacteremia, septicemia and infection of other organs. Young, stressed/sick or immunocompromised animals and those kept in high-density housing are at higher risk for clinical illness. The mortality rate from acute salmonellosis in dogs and cats is <10%.



Diagnosis of *Salmonella*

Bacterial culture: Definitive diagnosis of salmonellosis is typically made by bacterial culture, usually of the feces. However, because *Salmonella* can be found in healthy individuals, a positive culture alone does not necessarily indicate that the organism is the cause of the



patient's disease. Culture must be interpreted in combination with clinical findings and other test results. Isolation of *Salmonella* from tissues or fluid other than gastrointestinal content (e.g. blood, cerebrospinal fluid, tracheal aspirate) confirms systemic infection. It can be difficult to isolate *Salmonella* in the presence of other organisms, therefore enrichment and selective culture techniques are often employed, which may take longer than standard culture. It is important to inform the laboratory if *Salmonella* is suspected or a potential differential diagnosis.

Polymerase chain reaction (PCR): A PCR assay has been developed to detect *Salmonella* in dogs. It may be more sensitive than culture, but because of this it may also be more likely to detect low numbers of *Salmonella* or dead organisms that are only passing through the intestine and are not responsible for disease. The usefulness of PCR for diagnosis of salmonellosis is currently unclear.

Shedding of *Salmonella* is intermittent in dogs and cats, in terms of number and frequency of organisms shed, and within and between affected individuals, therefore testing of **multiple fecal samples may be necessary for diagnosis**.



Treatment of Salmonellosis

Gastrointestinal infection: In most cases, salmonellosis is subclinical in animals, and does not require specific treatment. Even with uncomplicated gastroenteritis, disease is often self-limiting and therefore may require only supportive therapy, including intravenous fluids to compensate for fluid loss in the diarrhea and anti-inflammatory medication. **The use of antimicrobials in these cases is very controversial.** Antimicrobials are primarily indicated to prevent systemic spread of the bacteria, not to kill *Salmonella* within the intestinal tract. Since systemic infection is uncommon in otherwise healthy animals (or people), specific drug therapy is likely unnecessary, and should be avoided for the same reasons as in healthy pets that are subclinical shedders (see below).



- ▶ **Treatment** (supportive or specific) **must always be accompanied by infection control measures** to prevent spread of the pathogen and prevent re-infection of the patient. **It is unknown how long an animal will take to clear a *Salmonella* infection**, but it is estimated that recovered animals may shed organisms for 4-6 weeks. This is likely strongly influenced by concurrent disease and the status of the animal's normal intestinal flora, and possibly the opportunity for re-infection.

Systemic infection: In animals and humans with systemic infection or septicemia, antimicrobial therapy is warranted, and should be based on the antimicrobial susceptibility of the cultured isolate. Chloramphenicol, trimethoprim-sulfa, fluoroquinolones and aminoglycosides are usually effective against *Salmonella*. Variable resistance to erythromycin, clindamycin, ampicillin, cephapirin and sulfonamides has been reported, and the greatest resistance is seen with streptomycin and tetracycline. Animals with severe clinical disease may require additional supportive therapy as well, including colloid support.

There is no indication to treat healthy pets that are shedding *Salmonella*. There is no evidence that antimicrobial therapy shortens the duration of shedding. It is possible that such treatment could contribute to the development of antimicrobial resistance, and even prolong shedding through further disruption of the normal intestinal microflora. **Probiotics** have also not been shown to be effective for eliminating shedding.

Salmonella **vaccines** have been developed for use in food-producing animals, but no vaccine products are available for dogs, cats, or humans. An effective vaccine for dogs and cats may not be possible due to the wide range of serotypes that may infect these species.

Infection Control For *Salmonella* in Pets

Control of salmonellosis in dogs and cats is very important from a human and public health perspective. Complete prevention can be very frustrating due to the number of animals that may be subclinical carriers and the viability of the organism in the environment. Any *Salmonella* infection of an animal, whether the animal is sick or not, should be considered potentially transmissible to humans, and vice versa. **Control of fecal contamination**, both human and animal, is of primary importance.





Hand Hygiene: Anyone **handling a pet or feces from a pet** should wash their hands immediately afterwards with soap and running water, or use an alcohol-based hand sanitizer. This is especially important in the case of animals with confirmed or suspected *Salmonella* infection (e.g. a pet with diarrhea, any pet that is fed raw meat), but applies to all animals, as even healthy pets can shed *Salmonella*. Hand hygiene is also critical:

- ▶ After using the bathroom
- ▶ After handling any kind of raw meat product
- ▶ Prior to handling any food
- ▶ After handling any kind of pet food

At Home & In Public:

- Dog feces should be picked up immediately to prevent environmental contamination, especially in public areas like parks where other dogs and children may play.
- Prevent pets from drinking from puddles, ponds, lakes or other water sources that may be contaminated with feces from other animals.
- Dogs should be strongly discouraged from eating their own feces or those of other animals.
- Thoroughly cook all food (especially meat) fed to pets.
- Feeding a commercially prepared, heat-processed diet helps to reduce the risk of *Salmonella* contamination in the food, but even these products can occasionally contain *Salmonella*. Pet food should therefore be kept in a sealed container and should never come in contact with kitchen surfaces or food meant for human consumption.
- Do not leave wet pet food in dishes at room temperature for prolonged periods, as this provides ideal conditions for bacteria of many kinds to grow.
- Prevent pets from hunting and scavenging small wild animals and birds. Dogs should be supervised carefully when off-leash. Cats should ideally be kept indoors.



Infection Control For Pets Carrying *Salmonella*

Any animal with a confirmed or suspected *Salmonella* infection should be kept separate from other animals, particularly young, geriatric, immunocompromised or otherwise sick pets. High-risk individuals (e.g. young, elderly and immunocompromised persons) should avoid contact with any known *Salmonella*-positive pet, but the animal does NOT need to be removed from the home if appropriate infection control measures are well followed.

Humans that are carriers of non-typhoid *Salmonella* may transmit the infection to dogs or cats, and should not be overlooked as potential sources of the bacteria if a pet becomes infected.

In-Clinic Precautions: All animals with acute diarrhea of unknown etiology should be considered infectious, because there are numerous infectious pathogens, including *Salmonella*, that could be the cause.

- Animals with acute diarrhea should be admitted directly to isolation or an examination room, and should not have contact with other animals in the reception area.
- Contact precautions (i.e. examination gloves and a gown or dedicated laboratory coat) should be used when handling affected animals.
- Use of an alcohol-based hand sanitizer or hand-washing with soap and water should be exercised after contact with the patient or areas that may have become contaminated, even if gloves are worn.
- Contaminated surfaces, particularly runs and kennels, must be thoroughly cleaned to remove all visible organic debris prior to applying a disinfectant. Use a 1:10 solution of bleach, ensuring that adequate contact time (at least 10-15 minutes) is permitted.
- Linens that become contaminated with fecal material should be washed separately and **dried completely using high heat** in a dryer. Washing alone, even in hot water, will not necessarily kill pathogens such as *Salmonella*. Large amounts of gross contamination should be removed by hand using gloves and disposable paper towel prior to washing.



Animals Fed Raw Meat

Feeding of raw meat to pets has been clearly associated with a significantly increased risk *Salmonella* carriage. Raw meat diets and feces from animals fed these diets may pose a risk to hospitalized animals and clinic personnel, and may contaminate the hospital environment. Therefore it should be clinic policy **NOT to feed raw meat** to hospitalized patients, unless changing the animal's diet would adversely affect its health, in the opinion of the attending veterinarian.

- ▶ **All pets that are regularly fed raw meat should be considered potential carriers of *Salmonella*, and managed with the same isolation precautions as diarrheic animals (as above).**



Pet treats made from raw animal tissues may also be contaminated with *Salmonella*, and outbreaks associated with these products have been reported. Raw treats such as **pig ears** and **rawhides** should be **handled in the same manner as raw meat**, and should not be given to dogs in households with high-risk (e.g. young, elderly or immunocompromised) individuals. The risk of transmission of *Salmonella* directly from dogs fed these treats (versus from the treats themselves) is unknown.

Considerations For Therapy Animals

Pets that visit healthcare facilities or are part of other animal visitation programs during which they may come in contact with individuals with compromised immune systems should not be fed raw meat due to the increased risk of shedding *Salmonella*. Guidelines have been developed to reduce the risk of pets involved in animal visitation programs acquiring or transmitting infectious diseases. Owners involved in these programs should ensure that they follow these guidelines.

Pet owners diagnosed with Salmonella

People can potentially transmit *Salmonella* to pets. Owners diagnosed with intestinal salmonellosis should be told to wash their hands thoroughly after using the washroom. Their pet(s) should be prevented from drinking from the toilet. There is no evidence that testing pets for *Salmonella* is useful if an owner is diagnosed with salmonellosis.

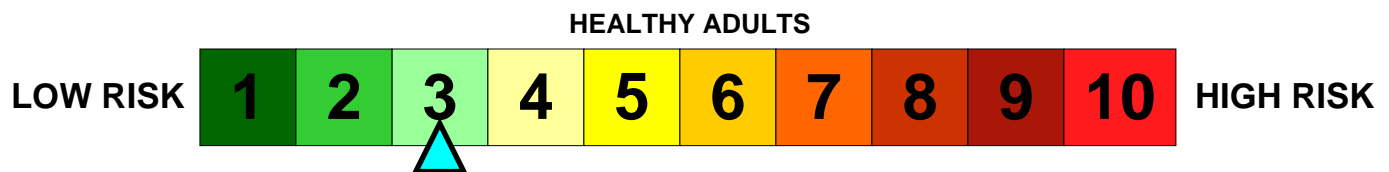


In general, **testing or treating clinically normal animals for Salmonella is not indicated**, but *Salmonella* should be considered in animals that develop diarrhea. Transmission of *Salmonella* from a pet to a human in a household is very unlikely if appropriate precautions (as described above) are observed. Even if there are high-risk individuals in the household, diligent attention to infection control measures will minimize the risk of transmission. Given the well-described benefits of pet ownership, **permanent removal of the pet is not indicated**, unless extenuating circumstances exist which prevent proper infection control measures from being implemented. In these cases, the **pet may be temporarily removed** until its carrier status resolves, but this would very rarely be warranted.

There is no indication to treat healthy pets that are shedding Salmonella.

Zoonotic Disease Risk

The zoonotic risk to the general population posed by *Salmonella* in house pets such as dogs and cats is:

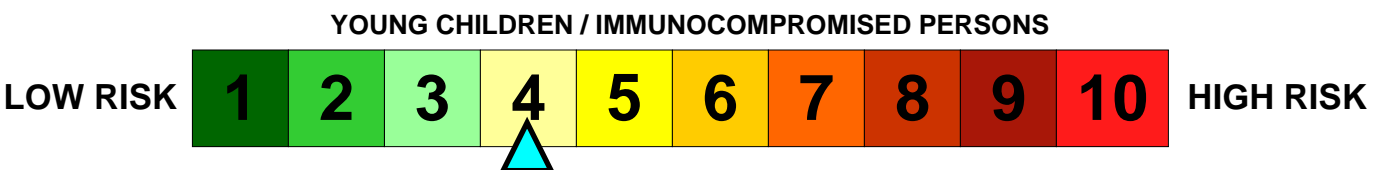


Individuals with compromised immune systems (e.g. HIV/AIDS, transplant and cancer patients) are more susceptible to many kinds of infections, including those which may be transmitted by pets. While these individuals are not advised to get rid of their pets, precautions should be taken to reduce the frequency of contacts that could result in pathogen transmission (e.g. avoiding contact with any animal feces), as well as the ability of infectious agents to survive in the household (e.g. prompt and thorough disinfection of potentially contaminated surfaces).

Infants and young children (less than 5 years old) are more likely than adults to extensively handle animals if given the opportunity, more likely to touch their faces or mouths, and less likely to wash their hands after handling an animal. Children may “snuggle” with pets; this very close contact can increase the risk of disease transmission.

- Young children should be supervised when playing with animals, and an adult should ensure that they wash their hands afterwards, and especially prior to handling food. Older children should be taught to do the same.

For these groups, the zoonotic risk posed by *Salmonella* in house pets such as dogs and cats is likely:





Reptiles & amphibians are of **considerably higher risk** for transmission of *Salmonella* compared to other pets. In people less than 21 years old in the USA, contact with reptiles or amphibians accounts for 11% of all sporadic *Salmonella* infections. These are therefore **NOT** recommended pets for any household with young children or individuals with a weakened immune system.

Additional Information

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