

Salmonellosis

*Paratyphoid,
Non-typhoidal Salmonellosis*

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Etiology

Salmonella spp. are members of the family Enterobacteriaceae. They are Gram negative, facultatively anaerobic rods. *Salmonella* species are classified into serovars (serotypes) based on the lipopolysaccharide (O), flagellar protein (H), and sometimes the capsular (Vi) antigens. There are more than 2500 known serovars. Within a serovar, there may be strains that differ in virulence.

Salmonella nomenclature

Salmonella nomenclature is not completely standardized. Several synonyms may be used for the same species or subspecies. Under the classification scheme used by the U.S. Centers for Disease Control and Prevention (CDC), World Health Organization (WHO) and some journals, there are now only two species in the genus *Salmonella*: *S. enterica* and *S. bongori*.

S. enterica has 6 subspecies: *S. enterica* subsp. *enterica*, *S. enterica* subsp. *salamae*, *S. enterica* subsp. *arizonae*, *S. enterica* subsp. *diarizonae*, *S. enterica* subsp. *houtenae* and *S. enterica* subsp. *indica*. These subspecies are also referred to by a number. *S. enterica* subsp. *enterica* = subspecies I. *S. enterica* subsp. *salamae* = subspecies II. *S. enterica* subsp. *arizonae* = subspecies IIIa. *S. enterica* subsp. *diarizonae* = subspecies IIIb. *S. enterica* subsp. *houtenae* = subspecies IV. *S. enterica* subsp. *indica* = subspecies VI.

Serovars in *S. enterica* subsp. *enterica* are referred to by name. The names of these serovars can be shortened from the full name to the genus and serovar. For example, *S. enterica* subsp. *enterica* ser. Enteritidis can be called *Salmonella* ser. Enteritidis or *Salmonella* Enteritidis.

Most of the serovars in the other 5 subspecies of *S. enterica*, as well as in *S. bongori*, are referred to by their antigenic formulas. These formulas include:

1. The subspecies/species designation (I, II, IIIa, IIIb, IV or VI for *S. enterica* subtypes; V for *S. bongori*);
2. O (somatic) antigens followed by a colon,
3. H (flagellar) antigens (phase 1) followed by a colon;
4. H antigens (phase 2, if present).

Using this convention, a *S. enterica* subsp. *houtenae* strain with an O antigen designated 45, H antigens designated g and z51, and no phase 2 H antigens would be written as *Salmonella* serotype IV 45:g,z51:.

Subspecies and serovars important in human disease

Most of the isolates that cause disease in humans and other mammals belong to *S. enterica* subsp. *enterica*. A few serovars - *Salmonella* ser. Typhi, *Salmonella* ser. Paratyphi and *Salmonella* ser. Hirschfeldii - are human pathogens. They are transmitted mainly from person to person and have no significant animal reservoirs. The remaining *Salmonella* serovars, sometimes referred to as non-typhoidal *Salmonella*, are zoonotic or potentially zoonotic. *S. bongori*, *S. enterica* subsp. *salamae*, *S. enterica* subsp. *arizonae*, *S. enterica* subsp. *diarizonae*, *S. enterica* subsp. *houtenae* and *S. enterica* subsp. *indica* are usually found in poikilotherms (including reptiles, amphibians and fish) and in the environment. Some of these organisms are occasionally associated with human disease.

Geographic Distribution

Salmonellosis can be found worldwide but seems to be most common where intensive animal husbandry is practiced. *Salmonella* eradication programs have nearly eliminated the disease in domestic animals and humans in some countries (e.g. Sweden), but reservoirs remain in wild animals. Serovars vary in their distribution. Some, such as *Salmonella* ser. Enteritidis and *Salmonella* ser. Typhimurium, are found worldwide. Others are limited to specific geographic regions.

In the U.S., the most common serotypes isolated from humans in 2002 were, in descending order: *Salmonella* Typhimurium, *Salmonella* Enteritidis, *Salmonella* ser. Newport, *Salmonella* ser. Heidelberg, *Salmonella* ser. Javiana, *Salmonella* ser. Montevideo, *Salmonella* ser. Muenchen, *Salmonella* ser. Oranienburg and *Salmonella* ser. Saintpaul.



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In 2002, the most common serovars from clinically ill animals reported to the CDC and the National Veterinary Services Laboratory (NVSL) were, in descending order: *Salmonella* Typhimurium, *Salmonella* Newport, *Salmonella* ser. Agona, *Salmonella* Heidelberg, *Salmonella* ser. Derby, *Salmonella* ser. Anatum, *Salmonella* ser. Choleraesuis, *Salmonella* Montevideo, *Salmonella* ser. Kentucky, *Salmonella* ser. Senftenberg and *Salmonella* ser. Dublin.

Transmission

Salmonella spp. are mainly transmitted by the fecal-oral route. They are carried asymptotically in the intestines or gall bladder of many animals, and are continuously or intermittently shed in the feces. They can also be carried latently in the mesenteric lymph nodes or tonsils; these bacteria are not shed, but can become reactivated after stress or immunosuppression. Fomites and mechanical vectors (insects) can spread *Salmonella*.

Vertical transmission occurs in birds, with contamination of the vitelline membrane, albumen and possibly the yolk of eggs. *Salmonella* spp. can also be transmitted *in utero* in mammals.

Animals can become infected from contaminated feed (including pastures), drinking water or close contact with an infected animal (including humans). Birds and rodents can spread *Salmonella* to livestock. Carnivores are also infected through meat, eggs and other animal products that are not thoroughly cooked. Cats sometimes acquire *Salmonella* Typhimurium after feeding on infected birds or spending time near bird feeders.

People are often infected when they eat contaminated foods of animal origin such as meat or eggs. They can also be infected by ingesting organisms in animal feces, either directly or in contaminated food or water. Directly transmitted human infections are most often acquired from the feces of reptiles, chicks and ducklings. Livestock, dogs, cats, adult poultry and cage birds can also be involved.

Salmonella spp. can survive for long periods in the environment, particularly where it is wet and warm. They can be isolated from many sources including farm effluents, human sewage and water. *Salmonella choleraesuis* has been isolated for up to 450 days from pig meat and for several months from feces or fecal slurries. *Salmonella typhimurium* and *Salmonella dublin* have been found for over a year in the environment.

Disinfection

Salmonella spp. are susceptible to many disinfectants including 1% sodium hypochlorite, 70% ethanol, 2% glutaraldehyde, iodine-based disinfectants, phenolics and formaldehyde. They can also be killed by moist heat (121°C for a minimum of 15 min) or dry heat (160-170°C for at least 1 hour). Roasts and steaks should be cooked to an internal temperature of at least 145°F (63°C), ground beef to 160°F (71°C), poultry parts to 170°F (77°C), and whole poultry to

180°F (82°C). Pasteurization of milk at 71.1°C for 15 seconds can also kill *Salmonella* spp.

Infections in Animals

Species Affected

Salmonella spp. have been found in all species of mammals, birds, reptiles and amphibians that have been investigated. Fish and invertebrates can also be infected. Infections are particularly prevalent in poultry, swine and reptiles. Among reptiles, infections have been found in turtles, tortoises, snakes and lizards (including chameleons and iguanas).

Some serovars have a narrow host range. For example, *Salmonella choleraesuis* causes disease in pigs, *Salmonella* ser. Abortusovis tends to be associated with sheep and *Salmonella* ser. Pullorum causes disease in poultry. However, most serovars can cause disease in a broad range of hosts.

All species seem to be susceptible to salmonellosis under the right conditions but clinical disease is more common in some animals than others. Clinical cases are common in cattle, pigs and horses but are relatively uncommon in cats and dogs.

Incubation Period

The incubation period in animals is highly variable. In many cases, infections become symptomatic only when the animal is stressed. In horses, severe infections can develop acutely, with diarrhea appearing after 6 to 24 hours.

Clinical Signs

Salmonella spp. are often carried asymptotically. Clinical disease usually appears when animals are stressed by factors such as transportation, crowding, food deprivation, weaning, parturition, exposure to cold, a concurrent viral or parasitic disease, sudden change of feed, or overfeeding following a fast. Salmonellosis is common in horses after major surgery. In some cases, oral antibiotics may also precipitate disease.

The clinical signs vary with the infecting dose, health of the host, *Salmonella* serovar and strain, and other factors. Some serovars tend to produce a particular syndrome: for example, in pigs *Salmonella* Choleraesuis is usually associated with septicemia and *Salmonella* Typhimurium with enteric disease. Although salmonellosis can be seen in all domestic animals, pregnant, lactating or young mammals and birds are the most susceptible.

Reptiles

Clinical disease seems to be uncommon in reptiles. Syndromes that have been reported include septicemia (characterized by anorexia, listlessness and death), osteomyelitis, osteoarthritis and subcutaneous abscesses. Progressive, fatal bone infections have been seen in snakes. In one group of free-living turtles, the symptoms included emaciation,

lesions of the plastron, a discolored carapace and intestinal, respiratory and hepatic lesions. *Salmonella* spp. have also been implicated in sporadic deaths among tortoises in zoos.

Ruminants, pigs and horses

The major syndromes in livestock are enteritis and septicemia. Acute enteritis is the most common form in adult animals, and in calves over a week old. This form is characterized by profuse diarrhea, dehydration, depression, abdominal pain and anorexia. The feces are watery to pasty, often foul smelling, and may contain mucus, pieces of mucous membrane, casts or blood. A fever occurs early in the infection, but can disappear by the time diarrhea develops. In dairy cows, milk production drops acutely. Intestinal salmonellosis usually lasts for 2 to 7 days. Death can occur as the result of dehydration and toxemia. Horses, in particular, often have severe enteritis and may die within 24 to 48 hours. Loss of condition, emaciation and unthriftiness may be seen in surviving livestock. Recovery can be slow.

Subacute enteritis may be seen in adult horses, cattle and sheep. The most obvious symptoms are persistent soft feces or diarrhea, and weight loss. There may also be mild fever, inappetence and some dehydration.

Chronic enteritis is mainly seen in older calves, adult cattle and growing pigs. The symptoms can include progressive emaciation, low-grade intermittent fever and inappetence. The feces are usually scant and may be normal or contain mucus, casts or blood. Rectal strictures can be sequelae in growing pigs.

Septicemia is the most common syndrome in very young calves, lambs and foals, and in pigs up to 6 months of age. The symptoms include marked depression, high fever and, often, death within 1 to 2 days. Diarrhea can occur in some animals. Central nervous system (CNS) signs or pneumonia may be seen in calves and pigs. Pigs may also develop a dark reddish or purple discoloration of the skin, particularly on the ears and ventral abdomen.

Pregnant animals may abort, either with or without other clinical signs. Serovars often associated with abortions include *Salmonella* Dublin in cattle, *Salmonella* Abortusovis in sheep and *Salmonella* ser. Abortusequi in horses. In cows with subacute enteritis, the first symptom may be abortion, followed after several days by diarrhea. Abortions in pregnant ewes may be followed by a fetid, dark red vaginal discharge and sometimes death.

Calves can develop complications such as joint infections or gangrene at the limb extremities, tips of the ears and tail.

Dogs and cats

In dogs and cats, the most common form is acute diarrhea with or without septicemia. Most cats and dogs with acute diarrhea recover within 3 to 4 weeks. Pneumonia, abscesses, meningitis, osteomyelitis, cellulitis or conjunctivitis may also be seen. A chronic febrile illness characterized

by anorexia and lethargy, but no diarrhea, has been reported in cats. Pregnant dogs and cats may abort or give birth to weak puppies or kittens.

Birds

Most clinical cases are seen in very young birds. The symptoms may include anorexia, lethargy, diarrhea, increased thirst and CNS signs.

Communicability

Salmonella spp. are shed in the feces of both symptomatic and asymptomatic animals. Reptiles shed the organism continuously or intermittently, and should always be considered a potential source of *Salmonella*. Livestock can become carriers of some serovars (e.g. *Salmonella* Dublin) for years and other serovars for a few weeks or months. Animals can also become passive carriers by constantly reacquiring *Salmonella* spp. from the environment. Most dogs and cats shed the organism for 3 to 6 weeks, continuously at first and then intermittently. Some dogs and cats can shed *Salmonella* spp. for up to three months.

Diagnostic Tests

Salmonellosis can be confirmed by isolating the organisms from feces or, in cases of disseminated disease, from the blood. After an abortion, the bacteria may be found in the placenta, vaginal exudate and fetal stomach. At necropsy, heart blood, bile, liver, spleen and mesenteric lymph nodes are collected. Embryonated eggs can be cultured from birds. *Salmonella* will grow on many selective and non-selective media including blood, MacConkey, eosin-methylene blue, bismuth sulfite, *Salmonella*-Shigella, and brilliant green agars. Enrichment media can increase the probability of isolating the organism by suppressing competing organisms. Intensive methods (pre-enrichment) to detect *Salmonella* are designed for food analysis but are sometimes used clinically. They can resuscitate stressed organisms and increase the probability that small numbers of organisms will be detected. Pre-enrichment, enrichment and selection of several colonies may be particularly useful for reptiles, which can carry several species of *Salmonella* simultaneously.

Salmonella spp. are identified with biochemical tests, and the serovar can be identified by serology for the somatic (O), flagellar (H) and capsular (Vi) antigens. Phage typing or plasmid profiling is also used for some serovars. Further characterization, if needed, can be carried out at a reference laboratory.

Diagnosis of clinical cases and identification of carriers are complicated by the following factors: Because *Salmonella* spp. can be found in healthy carriers, isolation of these bacteria from the feces is not a definitive diagnosis of salmonellosis. Reptiles may shed *Salmonella* spp. intermittently. Currently, it is impossible to determine whether an individual reptile is *Salmonella*-free. Asymptomatically infected mam-

mals may also excrete low numbers of bacteria intermittently. Repeated testing may be necessary to identify carriers.

Serology can be useful for diagnosis in a herd or flock. It is also used to identify carriers in poultry *Salmonella* eradication programs. Serologic tests include agglutination tests and enzyme-linked immunosorbent assays (ELISAs). Some ELISAs can be used for bulk milk screening or on freeze-thawed muscle tissue samples (tissue fluid) from pigs. Most serologic tests detect a limited number of serovars or serogroups. Serology is of limited use in individual animals, as antibodies do not appear until two weeks after infection, and antibodies may also be present in uninfected animals.

Polymerase chain reaction (PCR) and other genetic techniques may also be available.

Treatment

Septicemic salmonellosis can be treated with a number of antibiotics including ampicillin, amoxicillin, gentamicin, trimethoprim/sulfamethoxazole, third generation cephalosporins, chloramphenicol and fluoroquinolones. Many isolates are resistant to one or more antibiotics, and the choice of drugs should, if possible, be based on susceptibility testing.

Antibiotics can favor the persistence of *Salmonella* spp. in the intestines after recovery, affect the intestinal flora, and increase the emergence of antibiotic-resistant strains. For these reasons, antibiotics might not be used for enteric disease. Fluid replacement, correction of electrolyte imbalances and other supportive care is important in cases of enteritis.

Nonsteroidal anti-inflammatory drugs may be given to decrease the effects of endotoxemia. Antibodies to *Salmonella* lipopolysaccharide may also be used in some cases.

Prevention

The risk of introducing salmonellosis into a herd/flock can be decreased by buying animals or eggs from *Salmonella*-free sources, isolating newly acquired animals, and practicing “all in/all out” herd or flock management, where appropriate. Rodent control is also important. Feed and water sources should be *Salmonella*-free.

During a herd outbreak, carrier animals should be identified and either isolated and treated, or culled. Treated animals must be re-tested several times to ensure that they no longer carry *Salmonella*. Fecal contamination of feed and water supplies should be prevented. Contaminated buildings and equipment should be cleaned and disinfected, and contaminated material should be disposed of.

In many cases, elimination of *Salmonella* infections is impractical, and control is limited to preventing clinical disease and/or the transmission of bacteria to humans.

Clinical salmonellosis can be decreased by good hygiene and minimizing stressful events. Colostrum is important in preventing disease in young animals. Vaccines are available for some serovars such as *Salmonella* Dublin, *Salmonella*

Typhimurium, *Salmonella* Abortusequi and *Salmonella* Choleraesuis in some countries. Vaccines can reduce the level of colonization and shedding of *Salmonella* spp. into the environment, as well as clinical disease.

Competitive exclusion by administration of *Salmonella*-free cultures of fecal organisms may be used in young birds.

All reptiles should be considered to be potential sources of *Salmonella*. Currently, it is impossible to determine whether an individual reptile is free of these bacteria. The Association of Reptile and Amphibian Veterinarians (ARAV) discourages veterinarians from treating reptiles with antibiotics to eliminate *Salmonella*, as this has not been effective in the past and may increase the development of antibiotic-resistant strains of bacteria. Attempts to raise *Salmonella*-free reptiles have also been unsuccessful. Precautions to decrease the risk of *Salmonella* transmission from reptiles to humans, including client-education sheets, are available from the ARAV.

Morbidity and Mortality

In animals, asymptomatic *Salmonella* infections are common. Overall, approximately 1-3% of domestic animals are thought to carry *Salmonella* spp. but the prevalence can be much higher in some species. Estimates of the carrier rate among reptiles vary from 36% to more than 80-90%, and several serovars can be found in a single animal. Some authorities consider most or all reptiles to be *Salmonella* carriers. High prevalence rates can also be present in some birds and mammals. *Salmonella* spp. have been isolated from 41% of turkeys tested in California and 50% of chickens examined in Massachusetts. *Salmonella* spp. have also been isolated from 1-36% of healthy dogs and 1-18% of healthy cats in various studies, as well as 6% of beef cattle in feedlots. From 2-20% of horses are thought to be healthy shedders.

Among mammals, clinical disease is most common in very young, pregnant or lactating animals, and usually occurs after a stressful event. Outbreaks with a high morbidity rate and sometimes a high mortality rate are typical in young ruminants, pigs and poultry. In outbreaks of septicemia, the morbidity and mortality rates may approach 100%. Salmonellosis is uncommon in healthy, unstressed adult birds and mammals, and typically occurs as sporadic cases. Acute enteritis is particularly severe in horses, and the mortality rate for this species can approach 100%. Deaths or disease are occasionally reported in reptiles, but seem to be rare.

Post-Mortem Lesions [Click to view images](#)

The necropsy lesions, are not pathognomonic. They may include necrotizing fibrinous enteritis, lesions associated with septicemia or both.

Intestinal lesions are most common and severe in the lower ileum and large intestine. In acute enteritis, there is extensive hemorrhagic enteritis, with mucosal erosions and often whole blood in the lumen. Diphtheritic membranes

may be seen in some cases. Similar lesions may be found in the abomasum. The mesenteric lymph nodes are usually edematous and hemorrhagic, and there may be inflammation in the wall of the gall bladder. Other lesions may include fatty degeneration in the liver, bloodstained fluid in the serous cavities, and petechial hemorrhages in the heart and sometimes other organs.

In cattle with chronic salmonellosis, the intestinal wall is thickened and discrete areas of necrosis are usually found in the mucosa of the cecum and colon. An inflamed granular surface may be seen under the necrotic regions.

Infections in Humans

Incubation Period

The incubation period for *Salmonella* gastroenteritis in humans is usually 12 hours to 3 days. Enteric fever usually appears after 10 to 14 days.

Clinical Signs

In humans, salmonellosis varies from a self-limiting gastroenteritis to septicemia. Whether the organism remains in the intestine or disseminates depends on host factors as well as the virulence of the strain. Asymptomatic infections can also be seen.

All serovars can produce all forms of salmonellosis, although a given serotype is often associated with a specific syndrome (e.g. *Salmonella* Choleraesuis tends to cause septicemia). Salmonellosis acquired from reptiles is often severe, and may be fatal due to septicemia or meningitis. Most cases of reptile-associated salmonellosis are seen in children under 10 and people who are immunocompromised.

Gastroenteritis is characterized by nausea, vomiting, cramping abdominal pain and diarrhea, which may be bloody. Headache, fever, chills and myalgia may also be seen. Severe dehydration can occur in infants and the elderly. In many cases, the symptoms resolve spontaneously in 1 to 7 days. Deaths are rare except in very young, very old, debilitated or immunocompromised persons.

Enteric fevers are a severe form of systemic salmonellosis. Although most cases are caused by *S. typhi*, a human pathogen, other species can also cause this syndrome. Gastrointestinal disease may be the first sign, but it usually resolves before the systemic signs appear. The symptoms of enteric fever are non-specific and may include fever, anorexia, headache, lethargy, myalgias and constipation. This disease can be fatal, due to meningitis or septicemia, if not treated quickly.

Focal infections such as septic arthritis, abscesses, endocarditis or pneumonia are occasionally seen. Many tissues and organs can be affected.

Reiter's syndrome may be a sequela in some cases of gastroenteritis. This syndrome is characterized by mild to severe

arthritis, nonbacterial urethritis or cervicitis, conjunctivitis and small, painless, superficial mucocutaneous ulcers. Reiter's syndrome occurs in approximately 2% of cases of salmonellosis. It is also seen after other enteric infections. Reiter's syndrome usually resolves in 3 to 4 months, but approximately half of all patients experience transient relapses for several years. Chronic arthritis can occur in some cases.

Communicability

Salmonellosis can be transmitted to other people or to animals in the feces. Humans shed bacteria throughout the course of the infection. Shedding can last for several days to several weeks, and people may become temporary carriers for several months or longer. Approximately 0.3-0.6% of patients with non-typhoidal *Salmonella* infections shed the bacteria in the feces for more than a year. Antibiotic treatment can prolong shedding.

Diagnostic Tests

Salmonellosis can be confirmed by isolating the organisms from feces or, in cases of disseminated disease, from the blood. *Salmonella* will grow on a wide variety of selective and non-selective media including blood, MacConkey, eosin-methylene blue, bismuth sulfite, Salmonella-Shigella, and brilliant green agars. Enrichment broths can increase the probability of isolating the organism. Intensive methods to detect *Salmonella* (pre-enrichment) are primarily designed for food analysis but are sometimes used clinically, to resuscitate stressed organisms and increase the probability that small numbers of organisms will be detected.

Salmonella spp. are identified with biochemical tests, and the serovar can be identified using serology for the somatic (O), flagellar (H) and capsular (Vi) antigens. Phage typing or plasmid profiling is also used for some serovars. Further characterization, if needed, can be carried out at a reference laboratory.

PCR and other genetic techniques may also be available.

Treatment

Salmonellosis in humans can be treated with a number of antibiotics including ampicillin, amoxicillin, gentamicin, trimethoprim/sulfamethoxazole and fluoroquinolones. Many isolates are resistant to one or more antibiotics, and the choice of drugs should, if possible, be based on susceptibility testing. Antibiotics are used mainly for septicemia, enteric fever or focal extraintestinal infections. Focal infections may require surgery and prolonged courses of antibiotics.

In the elderly, infants and immunosuppressed persons, who are prone to septicemia and complications, antibiotics may be given for gastroenteritis. However most healthy people recover spontaneously in 2 to 7 days and may not require antibiotic treatment. Antibiotics do not usually shorten this form of the disease. They also prolong the period of bacterial shedding and increase the development of antibiotic-resis-

tant strains. Symptomatic treatment of dehydration, nausea and vomiting may be required.

Prevention

To decrease the risk of salmonellosis, both food safety practices and the prevention of transmission from animals are important.

To reduce the risk of food-borne disease:

- Raw or undercooked eggs, poultry and other meats should be avoided. All meat should be cooked until it is no longer pink in the middle.
- Unpasteurized milk and other unpasteurized dairy products should not be drunk or eaten.
- Raw vegetables should be thoroughly washed before eating.
- Cross-contamination of foods should be prevented. Uncooked meats should be kept separate from produce, cooked and ready-to-eat foods. The hands and any kitchen tools that contact uncooked foods should be thoroughly washed after handling potentially contaminated foods. The hands should also be washed before handling foods.
- Infants should not be fed or have their diapers changed while the caregiver is working with raw meats or eggs.

To reduce the risk of acquiring salmonellosis from animals:

- The hands should always be washed with hot, soapy water, immediately after contact with any animal feces.
- People who are immunocompromised should avoid contact with reptiles, young chicks and ducklings. They should also be particularly cautious when visiting farms or petting zoos. Other zoonosis prevention recommendations for those who are immunocompromised can be found on the CDC web site.

Extra precautions should be taken with reptiles, as many seem to shed *Salmonella* spp. Children under 10 seem to be particularly susceptible to severe salmonellosis after contact with reptiles.

- The hands should also be washed immediately after handling reptiles, their cages or other surfaces they have touched. It may also be a good idea to change clothing before close contact with infants.
- Children should be supervised when interacting with reptiles.
- Reptiles should not be allowed to roam freely in the home, particularly the kitchen, dining room or other areas where food is prepared or eaten.

- Reptiles and their equipment should be kept away from sinks, tubs and other areas where young children or infants may be bathed or food may be washed or prepared. A dedicated plastic tub should be used to bathe or swim reptiles. Waste water and fecal material should be disposed of in the toilet and not the bathtub or household sinks.
- Eating, drinking or smoking while handling reptiles or their environments should be avoided. Reptiles should not be kissed.
- Healthy reptiles fed a good diet and in a proper environment may be less likely to shed *Salmonella*.
- The CDC recommends that households with infants under a year of age should not keep reptiles, and children less than 5 avoid contact with reptiles. Reptiles should not be kept in day care centers.

No human vaccines to prevent zoonotic or foodborne salmonellosis exist. A vaccine is available to prevent typhoid fever, an infection transmitted from person to person.

Morbidity and Mortality

Salmonellosis is common in humans, and the incidence of disease seems to be increasing in the U.S. Approximately 30,000-40,000 cases are reported annually to the CDC but, because many cases are unreported, the actual incidence is thought to be 1.4 to 4 million infections each year. Large outbreaks are sometimes reported in hospitals, institutions and nursing homes, or linked to contaminated food. The rise in popularity of reptiles as pets has led to an increase in the number of reptile-associated cases. Currently, approximately 93,000 cases of salmonellosis each year are thought to be caused by reptiles.

Salmonellosis can affect all ages, but the incidence and severity of disease is higher in young children, the elderly, and people who are immunocompromised or have debilitating diseases. Children under 10 and immunocompromised persons seem to have an increased risk of contracting severe disease from reptiles.

Approximately 500-600 fatal cases of salmonellosis are reported each year in the U.S. The overall mortality rate for most forms of salmonellosis is less than 1%; however, some serovars or syndromes are more likely to be fatal. During outbreaks, approximately 10% of all cases and 18% of cases in the elderly result in invasive disease. The mortality rate for *Salmonella* Choleraesuis infections can be as high as 20%. In the elderly, septicemia due to *Salmonella* Dublin has a 15% mortality rate. In hospital or nursing home outbreaks, the mortality rate due to *Salmonella* Enteritidis is approximately 3.6%. *Salmonella* gastroenteritis is rarely fatal in healthy people.

Internet Resources

- Animal Health Australia. The National Animal Health Information System (NAHIS)
<http://www.aahc.com.au/nahis/disease/dislist.asp>
- Association of Reptile and Avian Veterinarians (ARAV)
<http://www.arav.org>
- ARAV Special Publications. Client Education Handout: Salmonella Bacteria and Reptiles:
<http://www.arav.org/salmonellaowner.htm>
- Centers for Disease Control and Prevention (CDC)
http://www.cdc.gov/ncidod/diseases/submenus/sub_salmonella.htm
- CDC Special Advice for People at Extra Risk for Zoonoses
http://www.cdc.gov/healthypets/extra_risk.htm
- International Veterinary Information Service (IVIS)
<http://www.ivis.org>
- Material Safety Data Sheets – Canadian Laboratory Center for Disease Control
<http://www.hc-sc.gc.ca/pphb-dgsp/msds-ftss/index.html#menu>
- Medical Microbiology
<http://www.gsbs.utmb.edu/microbook>
- OIE Manual of Diagnostic Tests and Vaccines for Terrestrial Animals
http://www.oie.int/eng/normes/mmanual/a_summry.htm
- The Merck Manual
<http://www.merck.com/pubs/mmanual/>
- The Merck Veterinary Manual
<http://www.merckvetmanual.com/mvm/index.jsp>
- U.S. FDA Foodborne Pathogenic Microorganisms and Natural Toxins Handbook (Bad Bug Book)
<http://vm.cfsan.fda.gov/~mow/intro.html>
- World Organization for Animal Health (OIE)
<http://www.oie.int/>

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