Salmonellosis

Paratyphoid, Nontyphoidal Salmonellosis

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Importance

Nontyphoidal *Salmonella* spp. are a leading cause of foodborne disease in humans worldwide. While gastroenteritis is the most common presentation in healthy adults, systemic disease can also occur, particularly in those who are immunocompromised including children and the elderly. Focal extraintestinal infections can also be seen. Salmonellosis is generally self-limiting in healthy people, although long term side effects can occur.

In animals, *Salmonella* spp. primarily cause enteritis and septicemia; however, many species carry the bacterium asymptomatically and shed it in their feces. Ingestion of contaminated animal products, such as eggs, poultry, pork, and other meats is a major route of transmission in humans. Outbreaks associated with non-animal foods, such as fresh produce and peanut butter, have been increasingly reported in recent years. Direct contact is also a potential route of transmission, particularly for high-risk animals such as reptiles, chicks and ducklings, although other animals may also transmit the bacterium to humans.

Resistance to antibiotics used to treat salmonellosis in humans and animals, including fluoroquinolones and third generation cephalosporins, is occurring in many parts of the world.

Etiology

Salmonella spp. are members of the family Enterobacteriaceae. They are gram negative, facultatively anaerobic rods. *Salmonella* spp. 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 has undergone many changes in recent years. According to the latest naming system, there are two recognized species in the genus *Salmonella*: *S. enterica* and *S. bongori*. A proposed third species, *Salmonella subterranean*, was identified in 2005 but has not been universally accepted.

S. enterica has six subspecies that are identified by name or number: *S. enterica* subsp. *enterica* (I), *S. enterica* subsp. *salamae* (II), *S. enterica* subsp. *arizonae (*IIIa), *S. enterica* subsp. *diarizonae* (IIIb*)*, *S. enterica* subsp. *houtenae* (IV) and *S. enterica* subsp. *indica* (VI). *S. bongori* is designated V. The complete, formal names of these serovars are often shortened. For example, *S. enterica* subsp. *enterica* ser. Enteritidis can be called *Salmonella* ser. Enteritidis or *Salmonella* Enteritidis.

Most of the 2500 serovars in the other five subspecies of *S. enterica*, as well as in *S. bongori*, are referred to by their antigenic formula. This formula includes the organism's subspecies/species number, O (somatic) antigen, phase I H (flagellar) antigen, and phase II H antigen. For example, 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.

Species Affected

Salmonella spp. have been found in all species of mammals, birds, reptiles and amphibians that have been investigated. These organisms have also been detected in fish and invertebrates. Asymptomatic infections are particularly prevalent in poultry, swine, reptiles and amphibians. Among reptiles, infections have been found in various species of turtles, tortoises, snakes and lizards (including chameleons and iguanas). Exotic animals such as pet hedgehogs and sugar gliders (*Petaurus breviceps*) can also be a source of human infection.

Some serovars have a narrow host range. For example, *Salmonella* ser. Abortusovis usually infects sheep, *Salmonella* ser. Choleraesuis usually infects pigs and *Salmonella* ser. Dublin usually infects cattle. *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.

Most *Salmonella* serovars can cause disease in a broad range of hosts. All species seem to be susceptible to salmonellosis under the right conditions but illness occurs more frequently in some animals than others. Clinical cases are common in cattle, pigs and horses but are relatively uncommon in cats and dogs.

Zoonotic potential

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 nontyphoidal *Salmonella*, are zoonotic or potentially zoonotic. The most common serovars infecting humans worldwide are *Salmonella* ser. Typhimurium and *Salmonell*a ser. Enteritidis. Serovars that have been isolated from ill humans include Newport, Javiana, I 4,[5],12:i:-, Muenchen, Bareilly, Montevideo, Heidelberg, Saintpaul and Infantis, among others.

Geographic Distribution

Salmonellosis occurs worldwide but seems to be most common where intensive animal husbandry is practiced. *Salmonella* eradication programs have nearly eliminated the disease in domesticated 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.

Transmission

Salmonella spp. are mainly transmitted by the fecal-oral route. They are carried asymptomatically in the intestines or gall bladder of many animals, and are continuously or intermittently shed in the feces. These bacteria are also shed in the feces of animals and humans that are ill. In addition, *Salmonella* spp. can 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 (e.g., insects such as flies) can also spread *Salmonella*.

Animals can become infected by ingestion of 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 (e.g., raw meat diets). Cats sometimes acquire *Salmonella* ser. Typhimurium after feeding on infected birds or spending time near bird feeders.

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. Reptiles and amphibians 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* ser. 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, but some shed for up to three months and possibly longer.

Humans

People are often infected when they eat contaminated foods of animal origin. Eggs are a major source of *Salmonella* in some countries, including the United States (U.S.). Meats such as poultry and pork are commonly implicated, but salmonellosis has also been caused by ingestion of contaminated beef, fish, and reptile meat, among others. Outbreaks associated with non-animal foods, such as fresh produce and peanut butter, have been increasingly reported in recent years. People can also be infected by ingesting organisms in contaminated water. Directly transmitted human infections are most often acquired from reptiles, amphibians, and poultry (e.g., chicks and ducklings) but other animals including livestock, pets, exotics, and rodents can also be a source of the bacterium. Rarely, people have been infected after contact with contaminated pet foods and treats.

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.

Salmonella spp. can survive for long periods in the environment and can be isolated from many sources. *Salmonella* ser. Choleraesuis can survive for at least 3 months in wet swine feces and 13 months in dry swine feces. *Salmonella* ser. Typhimurium has been isolated from cattle feces at 48 days; the bacterium may survive even longer in water (152 days) and soil (231 days). *Salmonella* spp. have also been cultured from foods such as produce, refrigerated dairy products, and frozen meat products for weeks to months.

Disinfection

Generally, gram negative bacteria such as *Salmonella* are susceptible to many disinfectants including 1% sodium hypochlorite, 70% ethanol, 70% propanol, 2% glutaraldehyde, and 4% formaldehyde, as well as phenol, peracetic acid, hydrogen peroxide, quaternary ammonium compounds, and iodophors. Salmonellae are resistant to nitrites.

They can also be killed by moist heat (121°C [250°F] for a minimum of 15 min) or dry heat (170°C [338°F] for at least 1 hour). Salmonellae are also susceptible to ozone.

Infections in Animals

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 asymptomatically. Illness usually appears when animals are stressed by factors such as transportation, mixing or 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* ser. Choleraesuis is usually associated with septicemia and *Salmonella* ser. Typhimurium with enteric disease. Although salmonellosis can be seen in all domesticated animals, pregnant, lactating or young mammals and birds are the most susceptible.

Reptiles

Clinical cases seem 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 clinical signs 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 occurs in adult animals and in young animals such as calves and crias over a week old. It 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 from several days to a week. 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 animals including 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 clinical signs 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.

Enteritis with septicemia is the most common syndrome in newborn calves, lambs, foals, fowl, and piglets. It may also be seen in pigs up to 6 months of age and occurs in adult animals. Signs 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 has been seen in calves and pigs and, rarely, crias.

Pregnant animals may abort, either with or without other clinical signs. Serovars often associated with abortions include *Salmonella* ser. Dublin in cattle, *Salmonella* ser. Abortusovis in sheep and *Salmonella* ser. Abortusequi in horses. In cows with subacute enteritis, the first sign 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

Clinical signs in dogs and cats are uncommon. Young and old dogs are most often affected. 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. Other syndromes such as 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. The majority of dogs and cats that shed *Salmonella* are not ill.

Birds

Salmonellosis seems to be rare in birds. Most clinical cases are seen in the very young. The clinical signs may include anorexia, lethargy, diarrhea, increased thirst and CNS signs.

Post-Mortem Lesions

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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.

Diagnostic Tests

Depending on the form of the disease, *Salmonella* may be detected in feces; placenta, fetal tissues and vaginal discharge; blood; or various internal organs at necropsy. Embryonated eggs can be cultured from birds. Intensive methods (pre-enrichment) to detect *Salmonella* can resuscitate stressed organisms and increase the probability that small numbers of organisms will be detected. *Salmonella* will grow on many selective and nonselective media. Pre-enrichment, enrichment and selection of several colonies may be particularly useful for reptiles, which can carry several species of *Salmonella* simultaneously. Fecal cultures, which are known to have low sensitivity, are often conducted serially to increase the likelihood of detecting bacteria. In horses, at least five samples should be cultured.

Salmonella spp. can be identified with biochemical tests, and the serovar can be identified by serology for the somatic (O), flagellar (H) and capsular (Vi) antigens. Although molecular methods are replacing phage typing and plasmid profiling, which have been used for further strain characterization in the past, many polymerase chain reaction (PCR) assays are not validated for clinical use with animal feces.

Diagnosis of clinical cases and identification of carriers is difficult. Because *Salmonella* spp. can be found in healthy carriers, isolation of these bacteria from the feces is not a definitive diagnosis of salmonellosis. Some animals, including reptiles, may shed *Salmonella* spp. intermittently, making it impossible to determine if an individual animal is *Salmonella*-free.

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.

Treatment

Uncomplicated cases of salmonellosis do not warrant treatment with antibiotics. This is because 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. Fluid replacement, correction of electrolyte imbalances and other supportive care is important in cases of enteritis.

Septicemic salmonellosis can be treated with a number of antibiotics. Many isolates are resistant to one or more antibiotics, and the choice of drugs should, if possible, be based on susceptibility testing. A combination of ampicillin and enrofloxacin has been recommended for empiric therapy in dogs. Additional therapies may include nonsteroidal anti-inflammatory drugs (given to decrease the effects of endotoxemia) and antibodies to *Salmonella* lipopolysaccharide.

Treatment of carrier animals, including reptiles, is not recommended to eliminate the bacterium from their intestinal tracts. Similarly, antibiotics are not recommended as an approach to control *Salmonella* in positive herds or flocks.

Prevention

In all animals, the risk of clinical salmonellosis can be decreased by good hygiene and minimizing stressful events. Colostrum is important in preventing disease in young animals.

Allowing animals to hunt or eat raw diets increases the risk that they may develop salmonellosis or carry *Salmonella* asymptomatically. Measures to prevent salmonellosis in pets, such as dogs and cats, include those that minimize consumption of raw foods. Feeding raw meat is not recommended; however, food bowls should be cleaned and uneaten food should be promptly picked up if access to raw animal products is allowed.

All reptiles, and likely amphibians, 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.

Biosecurity is the cornerstone of *Salmonella* prevention on the farm. The risk of introducing the bacterium 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. Additional methods to reduce *Salmonella*

colonization (e.g., dietary modification and feed supplementation in chickens) have also been investigated.

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*. Mixing of animals should also be avoided to decrease the spread of infection. 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 illnesses in animals and/or the transmission of bacteria to humans.

Livestock vaccines are available for some serovars such as *Salmonella* ser. Dublin, *Salmonella* ser. Typhimurium, *Salmonella* ser. Abortusequi and *Salmonella* ser. Choleraesuis in some countries. Vaccines can reduce the level of colonization and shedding of *Salmonella* spp. into the environment, as well as protect animals from illness.

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. Some authorities consider most or all reptiles and amphibians to be *Salmonella* carriers.

The prevalence of *Salmonella* spp. in birds and mammals is variable. Most studies have reported prevalence rates of 0–3.6% in healthy dogs. Higher rates are observed in shelter or stray dogs and cats, where up to 51% may be *Salmonella*-positive. The highest *Salmonella* prevalence rates occur in animals with exposure to raw foods, including animals fed commercial raw food diets, raw meat, and those allowed to hunt. In cattle, *Salmonella* prevalence seems to increase with time in the feedlot; one U.S. study detected *Salmonella* in 5.5% of feedlot cattle, with the highest rates occurring in those that had been on feed the longest.

Among mammals, clinical cases are most common in very young, pregnant or lactating animals, and usually occur 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.

Infections in Humans

Incubation Period

The incubation period for *Salmonella* gastroenteritis in humans is usually 6 hours to 3 days, although periods up to 14 days have been reported. Enteric fever usually appears after 10 to 14 days.

Clinical Signs

In humans, the severity of clinical disease varies. All serovars can produce all forms of salmonellosis, although a given serotype may be associated with a specific syndrome (e.g., *Salmonella* Choleraesuis tends to cause septicemia).

Gastroenteritis

Gastroenteritis caused by *Salmonella* is characterized by nausea, vomiting, cramping abdominal pain and diarrhea, which is not usually 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 several days to a week. Deaths are rare except in very young, very old, debilitated or immunocompromised persons. Complications related to gastrointestinal disease can include appendicitis, pancreatitis, cholecystitis, cholangitis, and abdominal or perianal abscess.

Systemic disease

Although systemic disease can take several forms, septicemia is most common. Invasive disease is most likely to occur when comorbidities are present; in developing countries, these often include malnutrition, malaria, and HIV.

Enteric fever, a multisystemic illness usually caused by the human pathogen *Salmonella* ser. Typhi, is uncommonly associated with nontyphoidal *Salmonella* spp. This disease is characterized by nonspecific febrile signs, sometimes preceded by gastrointestinal disease, and can result in fatal meningitis or septicemia if it is not treated quickly. Enteric fever tends to be less severe when it is caused by nontyphoidal *Salmonella* strains.

Focal disease

Extraintestinal manifestations occur most often in immunocompromised patients, including the young and old. Many tissues and organs can be affected. The lungs are the most commonly compromised organ. However, other conditions such as endocarditis, cholecystitis, hepatic and splenic abscesses, pneumonia, meningitis, and osteomyelitis can be seen.

Reactive arthritis (formerly known as Reiter syndrome) is a poorly defined immune response to infection that may be a sequela in some cases of gastroenteritis. This syndrome is characterized by mild to severe joint inflammation, together with urethritis, uveitis, or conjunctivitis. In one study, reactive arthritis occurred in approximately 4% of culture-proven cases of salmonellosis. It is also seen after other enteric infections. Reactive arthritis 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.

Diagnostic Tests

As in animals, salmonellosis can be confirmed by isolating the organisms from feces or, in cases of disseminated disease, from the bone marrow or blood. In humans, bone marrow cultures are considered to be most sensitive. When using blood and stool, multiple samples may be tested.

Treatment

There are variations in the recommended therapies for salmonellosis. Most cases of gastroenteritis caused by *Salmonella* spp. do not require antibiotic treatment. In fact, treatment is contraindicated since it may increase adverse effects and prolong *Salmonella* shedding. Treatment of healthy carriers is also not recommended.

Patients with severe salmonellosis (i.e., bacteremia, enteric fever, or focal infections) can be treated with a number of antibiotics including ampicillin, amoxicillin, gentamicin, trimethoprim/sulfamethoxazole, fluoroquinolones, and third generation cephalosporins (e.g., cefotaxime, ceftriaxone). In the elderly, infants and immunosuppressed persons, who are prone to septicemia and complications, antibiotics may be given for gastroenteritis. Choice of drugs should be based on susceptibility testing when possible.

Resistance to drugs used to treat salmonellosis has increased in recent years. In the U.S., about 100,000 drug-resistant *Salmonell*a infections occur each year according to the Centers for Disease Control and Prevention (CDC). About 5% of nontyphoidal *Salmonell*a infections are caused by multidrug resistant strains. Outside the U.S., antibiotic resistance is also a problem, particularly among fluoroquinolones and third generation cephalosporins.

In addition to supportive care, some infections require additional treatment. Surgery and prolonged courses of antibiotics may necessary for focal disease. Antimotility drugs are not recommended as they may prolong illness.

Prevention

To decrease the risk of salmonellosis, both food safety practices and the prevention of transmission from animals are important. Human-to-human transmission, though less common, can also be reduced through preventive measures. There is no human vaccine to prevent nontyphoidal salmonellosis.

Foodborne transmission

To reduce the risk of foodborne disease, proper food handling and preparation guidelines should be followed. Hands and surfaces, including utensils, cutting boards, dishes, and countertops, should be washed often. Both hot water and soap should be used. Cross-contamination of foods should be prevented. Uncooked meat, poultry, and seafood should be kept separate from fresh produce and cooked foods, and cutting boards and utensils should be cleaned between uses. Raw vegetables should be thoroughly washed before eating. All foods should be cooked to an appropriate internal temperature; raw or undercooked eggs, poultry, and other meats should be avoided. Foods should also be promptly refrigerated or frozen after cooking. Unpasteurized dairy products and untreated water should not be drunk or eaten.

Food preparers should be especially careful when making food for children, the elderly, or other immunocompromised people since they are more likely to develop severe disease. When caregivers are working with raw poultry or meat, infants should not be fed and diapers should not be changed.

Decreasing the prevalence of *Salmonella* in animals presumably decreases the risk of transmission to humans. In the European Union, *Salmonella* control programs have been relatively successful in reducing *Salmonella* prevalence in poultry, and corresponding reductions in human salmonellosis have been observed in some member states. These programs are usually based on implementing good hygiene and biosecurity standards, as well as keeping flocks free from disease. The U.S. has also recently released a *Salmonella* action plan. Post-harvest, carcass contamination is a significant problem. Various methods have been implemented to address slaughter hygiene, the slaughter process and storage routines, though none have been proven effective in preventing human disease.

Zoonotic transmission

To reduce the risk of acquiring salmonellosis from animals, hands should always be washed with hot, soapy water immediately after contact with animals, animal food or treats, animal bedding, and animal feces. Hand sanitizer should be used if soap and running water are not available. Children younger than five, the elderly, and people who are immunocompromised should not handle or touch high-risk animals (e.g., reptiles, frogs, young chicks and ducklings). They should also be particularly cautious around young livestock when visiting farms or petting zoos. High-risk animals should not be kept in child care centers.

Extra precautions should be taken with animals such as reptiles and amphibians, as many seem to shed *Salmonella* spp. The hands should be washed immediately after handling high-risk animals, their cages or other surfaces they have touched. Surfaces that have been in contact with these animals should be thoroughly cleaned. Cages, food and water bowls should be cleaned and disinfected outdoors if possible; alternatively, a dedicated plastic tub may be used. These items should not be cleaned in the kitchen sink or bath tubs. If immunocompromised individuals must handle high-risk animals or their habitats, gloves should be worn. These preventive measures also apply to other animals, such as hedgehogs and other exotic pets, which seem to be emerging *Salmonella* reservoirs.

In the home, children should be supervised when interacting with reptiles, amphibians, and poultry. Reptiles and amphibians should not be allowed to roam freely, particularly the kitchen, dining room or other areas where food is prepared or eaten. Eating, drinking or smoking while handling these animals or their environments should be avoided. Reptiles, amphibians, and young poultry (e.g., chicks, ducklings) should not be kissed. The CDC recommends that households with children less than five years of age or other immunocompromised people should not own reptiles, including turtles. Reptiles should not be kept in other places that young children frequent, such as child care centers or nursery schools.

Immunocompromised people should also use caution when handling pets with diarrhea, including dogs and cats. Direct contact with feces should be avoided and good hygiene should be practiced.

Human-to-human transmission

To make human-to-human transmission of *Salmonella* less likely, good hygiene is essential. In addition, people who are ill should not prepare food for others. Professional food handlers should report illness to their supervisors. In the U.S., restaurant workers may be required to show a negative stool test before returning to work. There is no vaccine to prevent nontyphoidal salmonellosis.

Morbidity and Mortality

Salmonellosis is common in humans. Globally, an estimated 93.8 million cases of gastroenteritis and 155,000 deaths are caused by nontyphoidal *Salmonella* spp. annually. Underreporting is a problem worldwide. In the U.S., the incidence of salmonellosis has remained relatively stable in recent years. About 16 cases were reported per 100,000 people in 2012; however, for every reported case an estimated 29 undiagnosed cases occur. In the EU, reported cases of salmonellosis have been decreasing. In 2011, about 20 cases were reported per 100,000 people. Surveillance data are often not available in developing countries. In Southeast Asia, it is estimated that 22.8 cases of salmonellosis occur each year.

Salmonellosis occurs most commonly in people who are immunocompromised, including children and the elderly. Most cases of reptile-associated salmonellosis are seen in children under 10 and people who are immunocompromised. Children under six months seem to be especially at risk for invasive reptile-associated disease.

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. Live poultry remain an important source of *Salmonella*. *Salmonella* spp. are also a frequent cause of traveler's diarrhea, particularly among those visiting Latin America and the Caribbean, Asia, and Africa.

The overall mortality rate for most forms of salmonellosis is less than 1%. In hospital or nursing home outbreaks, the mortality rate can be up to 70 times higher. *Salmonella* gastroenteritis is rarely fatal in healthy people.

Internet Resources

Association of Reptile and Avian Veterinarians (ARAV)
http://www.arav.org/special-topics/

Centers for Disease Control and Prevention (CDC)
http://www.cdc.gov/salmonella/

CDC Special Advice for People at Extra Risk for Zoonoses
http://www.cdc.gov/healthypets/extra_risk.htm

Fight BAC: Partnership for Food Safety Education
http://www.fightbac.org/

International Veterinary Information Service (IVIS)
http://www.ivis.org

Pathogen Safety Data Sheets – Public Health Agency of Canada
http://www.phac-aspc.gc.ca/lab-bio/res/psds-ftss/index-eng.php

OIE Manual of Diagnostic Tests and Vaccines for Terrestrial Animals
http://www.oie.int/en/international-standard-setting/terrestrial-manual/access-online/

The Merck Manual
http://www.merckmanuals.com/professional/index.html

The Merck Veterinary Manual
http://www.merckmanuals.com/vet/index.html

U.S. FDA Foodborne Pathogenic Microorganisms and Natural Toxins Handbook (Bad Bug Book)
http://www.fda.gov/Food/FoodborneIllnessContaminants/CausesOfIllnessBadBugBook/

World Organization for Animal Health (OIE)
http://www.oie.int/

References

Acha PN, Szyfres B (Pan American Health Organization [PAHO]). Zoonoses and communicable diseases common to man and animals. Volume 1. Bacterioses and mycoses. 3rd ed. Washington DC: PAHO; 2003. Scientific and Technical Publication No. 580. Salmonellosis; p. 233-251.

Agunos A, Léger D, Carson C. Review of antimicrobial therapy of selected bacterial diseases in broiler chickens in Canada. Can Vet J. 2012;53(12):1289-300.

Aiello SE, Moses MA. The Merck veterinary manual [online]. Overview of salmonellosis. Whitehouse Station, NJ: Merck and Co; Mar 2012. Available at: http://www.merckmanuals.com/vet/digestive_system/salmonellosis/overview_of_salmonellosis.html?qt=salmonellosis&alt=sh. Accessed 3 Dec 2013.

Aiken AM, Lane C, Adak GK. Risk of *Salmonella* infection with exposure to reptiles in England, 2004-2007. Euro Surveill. 2010;15(22):19581.

Anderson NV, Anderson DE, Leipold HW, Kennedy GA, Repenning L, Strathe GA. Septicemic salmonellosis in two llamas. J Am Vet Med Assoc. 1995;206(1):75-6.

Animal Health Australia. National Animal Health Information System (NAHIS). *Salmonella*. NAHIS; 1996 Oct. Available at: http://www.aahc.com.au/nahis/disease/dislist.asp.* Accessed 10 Jan 2005.

Arguello H, Alvarez-Ordoñez A, Carvajal A, Rubio P, Prieto M. Role of slaughtering in *Salmonella* spreading and control in pork production. J Food Prot. 2013;76(5):899-911.

Association of Reptile and Amphibian Veterinarians [ARAV]. Client educational handout: *Salmonella* bacteria and reptiles. Available at: http://www.arav.org/wp-content/uploads/2013/03/Salmonella-Information-for-Reptile-Owners.pdf. Accessed 5 Dec 2013.

Berger CN, Sodha SV, Shaw RK, Griffin PM, Pink D, Hand P, Frankel G. Fresh fruit and vegetables as vehicles for the transmission of human pathogens. Environ Microbiol. 2010;12(9):2385-97.

Boever WJ, Williams J. Arizona septicemia in three boa constrictors. Vet Med Small Anim Clin. 1975;70:1357-9.

Bradley T, Angulo FJ. *Salmonella* and reptiles: veterinary guidelines. Association of Reptile and Amphibian Veterinarians [ARAV]. Available at: http://www.arav.org/wp-content/uploads/2013/03/Salmonella-Information-for-Veterinarians.pdf. Accessed 5 Dec 2013.

Brenner FW, Villar RG, Angulo FJ, Tauxe R, Swaminathan B. *Salmonella* nomenclature. J Clinical Microbiol. 2000;38:2465-67.

Brooks JT, Matyas BT, Fontana J, DeGroot MA, Beuchat LR, Hoekstra M, Friedman CR. An outbreak of *Salmonella* serotype Typhimurium infections with an unusually long incubation period. Foodborne Pathog Dis. 2012;9(3):245-8.

Centers for Disease Control and Prevention [CDC]. Antibiotic resistance threats in the United States, 2013 [online]. Available at: http://www.cdc.gov/drugresistance/threat-report-2013/. Accessed 11 Dec 2013.

Centers for Disease Control and Prevention [CDC]. Foodborne diseases active surveillance network (FoodNet) tables and figures—2012 preliminary data. Available at: http://www.cdc.gov/foodnet/data/trends/tables-2012.html. Accessed 5 Dec 2013.

Centers for Disease Control and Prevention [CDC]. Multistate outbreak of human *Salmonella* infections caused by contaminated dry dog food--United States, 2006-2007. MMWR Morb Mortal Wkly Rep. 2008;57(19):521-4.

Centers for Disease Control and Prevention [CDC]. Notes from the field: Human *Salmonella* Infantis infections linked to dry dog food--United States and Canada, 2012. MMWR Morb Mortal Wkly Rep. 2012;61(23):436.

Centers for Disease Control and Prevention [CDC]. Reports of selected *Salmonella* outbreak investigations [online]. 2013 Oct. http://www.cdc.gov/salmonella/outbreaks.html. Accessed 14 Dec 2013.

Centers for Disease Control and Prevention [CDC]. Reptiles, amphibians, and *Salmonella* [online]. CDC; 2013 Nov. Available at: http://www.cdc.gov/features/salmonellafrogturtle/. Accessed 11 Dec 2013.

Centers for Disease Control and Prevention [CDC]. Reptile-associated salmonellosis--selected states, 1998-2002. Morb Mortal Wkly Rep. 2003;52:1206-9.

Centers for Disease Control and Prevention [CDC]. *Salmonella* infection (salmonellosis) and animals [online]. CDC; 2012 Aug Available at: http://www.cdc.gov/healthypets/diseases/salmonellosis.htm. Accessed 10 Dec 2013.

Centers for Disease Control and Prevention [CDC]. *Salmonella*. Technical information [online]. CDC; 2013 Jan. Available at: http://www.cdc.gov/salmonella/general/technical.html. Accessed 6 Dec 2013.

Centers for Disease Control and Prevention [CDC]. Salmonellosis [online]. CDC; 2013 May. Available at: http://www.cdc.gov/salmonella/. Accessed 6 Dec 2013.

Centers for Disease Control and Prevention [CDC]. Trends in Foodborne Illness in the United States, 2012. Available at: http://www.cdc.gov/features/dsfoodnet2012/reportcard.html. Accessed 5 Dec 2013.

Chatterje A. Pediatric *Salmonella* infection. 2012 Aug. eMedicine [online]. Available at: http://emedicine.medscape.com/article/968672-overview. Accessed 11 Dec 2013.

Dallap Schaer BL, Aceto H, Caruso MA 3rd, Brace MA. Identification of predictors of *Salmonella* shedding in adult horses presented for acute colic. J Vet Intern Med. 2012;26(5):1177-85.

D'Alterio GL, Bazeley KJ, Pearson GR, Jones JR, Jose M, Woodward MJ. Meningitis associated with *Salmonella* Newport in a neonatal alpaca (Lama pacos) in the United Kingdom. Vet Rec. 2003;152(2):56-7.

European Food Safety Authority [EFSA], European Centre for Disease Prevention and Control [ECDC]. The European Union summary report on trends and sources of zoonoses, zoonotic agents, and food-borne outbreaks in 2011. EFSA Journal 2013;11(4):3129.

Euzéby, J.P. List of bacterial names with standing in nomenclature. *Salmonella* nomenclature [monograph online]. Available at: http://www.bacterio.net/-salmonellanom.html. Accessed 12 Dec 2013.

Finley R, Ribble C, Aramini J, Vandermeer M, Popa M, Litman M, Reid-Smith R. The risk of salmonellae shedding by dogs fed *Salmonella*-contaminated commercial raw food diets. Can Vet J. 2007;48(1):69-75.

Feasey NA, Dougan G, Kingsley RA, Heyderman RS, Gordon MA. Invasive non-typhoidal *Salmonella* disease: an emerging and neglected tropical disease in Africa. Lancet. 2012;379(9835):2489-99.

Gordon MA. Invasive nontyphoidal *Salmonella* disease: epidemiology, pathogenesis and diagnosis. Curr Opin Infect Dis. 2011;24(5):484-9

Greene CE. Infectious diseases of the dog and cat. 4th edition. St. Louis, MO: Elsevier Saunders; 2012. Enteric bacterial infections; p. 386.

Haeusler GM, Curtis N. Non-typhoidal *Salmonella* in children: microbiology, epidemiology and treatment. Adv Exp Med Biol. 2013;764:13-26.

Hydeskov HB, Guardabassi L, Aalbaek B, Olsen KE, Nielsen SS, Bertelsen MF. *Salmonella* prevalence among reptiles in a zoo education setting. Zoonoses Public Health. 2013;60(4):291-5.

Isaza R, Garner M, Jacobson E. Proliferative osteoarthritis and osteoarthrosis in 15 snakes. J Zoo Wildl Med. 2000;31:20-7.

Jacobson ER. Infectious diseases of reptiles. College of Veterinary Medicine, University of Florida; 2000 Apr. Available at: http://iacuc.ufl.edu/OLD%20Web%20Site/infectiousdis.htm. Accessed 20 Jan 2005.

Kendall ME, Crim S, Fullerton K, Han PV, Cronquist AB, Shiferaw B, Ingram LA, Rounds J, Mintz ED, Mahon BE. Travel-associated enteric infections diagnosed after return to the United States, Foodborne Diseases Active Surveillance Network (FoodNet), 2004-2009. Clin Infect Dis. 2012;54 Suppl 5:S480-7.

Klochko A. Salmonellosis. 2013 Dec. eMedicine [online]. Available at: http://emedicine.medscape.com/article/228174-overview. Accessed 11 Dec 2013.

Lal A, Hales S, French N, Baker MG. Seasonality in human zoonotic enteric diseases: a systematic review. PLoS One. 2012;7(4):e31883.

Lefebvre SL, Reid-Smith R, Boerlin P, Weese JS. Evaluation of the risks of shedding Salmonellae and other potential pathogens by therapy dogs fed raw diets in Ontario and Alberta. Zoonoses Public Health. 2008;55(8-10):470-80.

Marks SL, Rankin SC, Byrne BA, Weese JS. Enteropathogenic bacteria in dogs and cats: diagnosis, epidemiology, treatment, and control. J Vet Intern Med. 2011;25(6):1195-208.

Magnino S, Colin P, Dei-Cas E, Madsen M, McLauchlin J, Nöckler K, Maradona MP, Tsigarida E, Vanopdenbosch E, Van Peteghem C.Biological risks associated with consumption of reptile products. Int J Food Microbiol. 2009;134(3):163-75.

Majowicz SE, Musto J, Scallan E, Angulo FJ, Kirk M, O'Brien SJ, Jones TF, Fazil A, Hoekstra RM; International collaboration on enteric disease 'Burden of Illness' studies. Clin Infect Dis. 2010;50(6):882-9.

Medalla F, Hoekstra RM, Whichard JM, Barzilay EJ, Chiller TM, Joyce K, Rickert R, Krueger A, Stuart A, Griffin PM. Increase in resistance to ceftriaxone and nonsusceptibility to ciprofloxacin and decrease in multidrug resistance among *Salmonella* strains, United States, 1996-2009. Foodborne Pathog Dis. 2013;10(4):302-9.

McCoy E, Morrison J, Cook V, Johnston J, Eblen D, Guo C. Foodborne agents associated with the consumption of aquaculture catfish. J Food Prot. 2011;74(3):500-16.

McKenzie E, Riehl J, Banse H, Kass PH, Nelson S Jr, Marks SL. Prevalence of diarrhea and enteropathogens in racing sled dogs. J Vet Intern Med. 2010;24(1):97-103.

Morley PS, Strohmeyer RA, Tankson JD, Hyatt DR, Dargatz DA, Fedorka-Cray PJ. Evaluation of the association between feeding raw meat and *Salmonella* enterica infections at a Greyhound breeding facility. J Am Vet Med Assoc. 2006;228(10):1524-32.

National Association of State Public Health Veterinarians Animal Contact Compendium Committee 2013. Compendium of measures to prevent disease associated with animals in public settings, 2013. J Am Vet Med Assoc. 2013;243(9):1270-88.

Office International des Epizooties [OIE]. Manual of diagnostic tests and vaccines for terrestrial animals. OIE; 2013. Salmonellosis. Available at: http://www.oie.int/international-standard-setting/terrestrial-manual/access-online/. Accessed 4 Dec 2013.

Porter RS, Kaplan JL. The Merck manual [online]. Whitehouse Station, NJ: Merck and Co; Aug 2009. *Salmonella* infections. Available at: http://www.merckmanuals.com/professional/infectious_diseases/gram-negative_bacilli/salmonella_infections.html?qt=Infectious%20diseases%20caused%20by%20Gram%20negative%20bacilli.%20&alt=sh. Accessed 5 Dec 2013.

Porter RS, Kaplan JL. The Merck manual [online]. Whitehouse Station, NJ: Merck and Co; Nov 2012. Reactive arthritis. Available at: http://www.merckmanuals.com/professional/musculoskeletal_and_connective_tissue_disorders/joint_disorders/reactive_arthritis.html?qt=reactive%20arthritis&alt=sh

Public Health Agency of Canada. Pathogen Safety Data Sheet: *Salmonella enterica* spp. [online]. Pathogen Regulation Directorate, Public Health Agency of Canada; 2011 Feb. Available at: http://www.phac-aspc.gc.ca/lab-bio/res/psds-ftss/salmonella-ent-eng.php. Accessed 10 Dec 2013.

Ramsay EC, Daniel GB, Tryon BW, Merryman JI, Morris PJ, Bemis DA. Osteomyelitis associated with *Salmonella enterica* SS *arizonae* in a colony of ridgenose rattlesnakes (*Crotalus willardi*). J Zoo Wildl Med. 2002;33:301-10.

Rhoades JR, Duffy G, Koutsoumanis K. Prevalence and concentration of verocytotoxigenic *Escherichia coli, Salmonella enterica* and *Listeria monocytogenes* in the beef production chain: a review. Food Microbiol. 2009;26(4):357-76.

Riley PY, Chomel BB. Hedgehog zoonoses. Emerg Infect Dis. 2005;11(1):1-5.

Robinson J. Antimicrobials for non-typhoidal *Salmonella* infection—does it work?. Evid-Based Child Health. 2013;8: 759–760.

Ross AG, Olds GR, Cripps AW, Farrar JJ, McManus DP. Enteropathogens and chronic illness in returning travelers. N Engl J Med. 2013;368(19):1817-25.

Sánchez-Vargas FM, Abu-El-Haija MA, Gómez-Duarte OG. *Salmonella* infections: an update on epidemiology, management, and prevention. Travel Med Infect Dis. 2011;9(6):263-77.

Sauteur PM, Relly C, Hug M, Wittenbrink MM, Berger C. Risk factors for invasive reptile-associated salmonellosis in children. Vector Borne Zoonotic Dis. 2013;13(6):419-21.

Schroter M, Roggentin P, Hofmann J, Speicher A, Laufs R, Mack D. Pet snakes as a reservoir for *Salmonella enterica* subsp. *diarizonae* (Serogroup IIIb): a prospective study. Appl Environ Microbiol. 2004;70:613-5.

Sting R, Ackermann D, Blazey B, Rabsch W, Szabo I. *Salmonella* infections in reptiles--prevalence, serovar spectrum and impact on animal health. Berl Munch Tierarztl Wochenschr. 2013;126(5-6):202-8.

Taylor DJ, Philbey AW. *Salmonell*a infections in garden birds and cats in a domestic environment. Vet Rec. 2010;167(1):26-7.

Tibary A, Fite C, Anouassi A, Sghiri A. Infectious causes of reproductive loss in camelids. Theriogenology. 2006;66(3):633-47.

Townes JM. Reactive arthritis after enteric infections in the United States: the problem of definition. Clin Infect Dis. 2010;50(2):247-54.

Tuompo R, Hannu T, Mattila L, Siitonen A, Leirisalo-Repo M. Reactive arthritis following *Salmonella* infection: a population-based study. Scand J Rheumatol. 2013;42(3):196-202.

United States Department of Agriculture, Food Safety and Inspection Service [USDA FSIS], Progress report on *Salmonella* and *Campylobacter* testing of raw meat and poultry products, 1998-2012. USDA FSIS; 2012. Available at: http://www.fsis.usda.gov/wps/wcm/connect/8d792eef-f44d-4ccb-8e25-ef5bdb4c1dc8/Progress-Report-Salmonella-Campylobacter-CY2012.pdf?MOD=AJPERES. Accessed 20 Dec 2013.

United States Department of Agriculture, Food Safety and Inspection Service [USDA FSIS], *Salmonella* questions and answers. USDA FSIS;2013 Aug. Available at: http://www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/get-answers/food-safety-fact-sheets/foodborne-illness-and-disease/salmonella-questions-and-answers/. Accessed 4 Dec 2013.

United States Department of Agriculture. National Antimicrobial Resistance Monitoring System, Enteric Bacteria Animal Arm (NARMS): 2010 NARMS Animal Arm Annual Report. Athens, GA: U.S. Department of Agriculture, Agricultural Research Service, 2012. Available at: http://ars.usda.gov/SP2UserFiles/Place/66120508/NARMS/NARMS2010/NARMS%20USDA%202010%20Report.pdf. Accessed 16 Dec 2013.

United States Food and Drug Administration [FDA], Center for Food Safety and Applied Nutrition [CFSAN]. *Salmonella* spp. [monograph online]. In: Foodborne pathogenic microorganisms and natural toxins handbook. 2nd ed. FDA-CFSAN; 2012. Available at: http://www.fda.gov/Food/FoodborneIllnessContaminants/CausesOfIllnessBadBugBook/. Accessed 9 Dec 2013.

Van TT, Nguyen HN, Smooker PM, Coloe PJ. The antibiotic resistance characteristics of non-typhoidal *Salmonella enterica* isolated from food-producing animals, retail meat and humans in South East Asia. Int J Food Microbiol. 2012;154(3):98-106.

Vandeplas S, Dubois Dauphin R, Beckers Y, Thonart P, Théwis A. *Salmonella* in chicken: current and developing strategies to reduce contamination at farm level. J Food Prot. 2010;73(4):774-85.

Vora NM, Smith KM, Machalaba CC, Karesh WB. Reptile- and amphibian-associated salmonellosis in childcare centers, United States. Emerg Infect Dis. 2012;18(12):2092-4.

Wales AD, Carrique-Mas JJ, Rankin M, Bell B, Thind BB, Davies RH. Review of the carriage of zoonotic bacteria by arthropods, with special reference to *Salmonella* in mites, flies and litter beetles. Zoonoses Public Health. 2010;57(5):299-314.

Wattiau P, Boland C, Bertrand S. Methodologies for *Salmonella enterica* subsp. *enterica* subtyping: gold standards and alternatives. Appl Environ Microbiol. 2011;77(22):7877-85.

Weese JS. Bacterial enteritis in dogs and cats: diagnosis, therapy, and zoonotic potential. Vet Clin North Am Small Anim Pract. 2011;41(2):287-309.

Weese JS, Rousseau J, Arroyo L. Bacteriological evaluation of commercial canine and feline raw diets. Can Vet J. 2005;46(6):513-6.

Weir M, Rajić A, Dutil L, Cernicchiaro N, Uhland FC, Mercier B, Tuševljak N. Zoonotic bacteria, antimicrobial use and antimicrobial resistance in ornamental fish: a systematic review of the existing research and survey of aquaculture-allied professionals. Epidemiol Infect. 2012;140(2):192-206.

Wikswo ME, Hall AJ; Centers for Disease Control and Prevention. Outbreaks of acute gastroenteritis transmitted by person-to-person contact--United States, 2009-2010. MMWR Surveill Summ. 2012;61(9):1-12.

Willis C, Wilson T, Greenwood M, Ward L. Pet reptiles associated with a case of salmonellosis in an infant were carrying multiple strains of *Salmonella*. J Clin Microbiol. 2002;40:4802-3.

Woodward DL, Khakhria R, Johnson WM. Human salmonellosis associated with exotic pets. J Clin Microbiol. 1997;35(11):2786-90.

Younus M, Wilkins MJ, Davies HD, Rahbar MH, Funk J, Nguyen C, Siddiqi AE, Cho S, Saeed M. Case-control study of disease determinants for non-typhoidal *Salmonella* infections among Michigan children. BMC Res Notes. 2010;3:105.

Younus M, Wilkins MJ, Davies HD, Rahbar MH, Funk J, Nguyen C, Siddiqi AE, Cho S, Saeed AM. The role of exposures to animals and other risk factors in sporadic, non-typhoidal *Salmonella* infections in Michigan children. Zoonoses Public Health. 2010;57(7-8):e170-6.

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