

Human Health Implications of *Salmonella*-Contaminated Natural Pet Treats and Raw Pet Food

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Human salmonellosis occurs mainly as a result of handling or consuming contaminated food products, with a small percentage of cases being related to other, less well-defined exposures, such as contact with companion animals and natural pet treats. The increasing popularity of raw food diets for companion animals is another potential pet-associated source of *Salmonella* organisms; however, no confirmed cases of human salmonellosis have been associated with these diets. Pets that consume contaminated pet treats and raw food diets can be colonized with *Salmonella* organisms without exhibiting clinical signs, making them a possible hidden source of contamination in the household. Pet owners can reduce their risk of acquiring *Salmonella* organisms by not feeding natural pet treats and raw food diets to their pets, whereas individuals who investigate cases of salmonellosis or interpret surveillance data should be aware of these possible sources of *Salmonella* organisms.

Dogs and cats play an integral part in the lives of humans, providing security, labor, therapeutic support, and companionship. In 2002 in the United States, dog and cat populations were estimated to comprise 65 million and 78 million animals, respectively [1]. Dogs are present in 39% of US households, and cats are present in 34% of US households [1]. Dogs and cats live in close contact with their owners, sharing their homes and immediate environment. In 2002, 41% of dogs and 53% of cats were reported to share their owner's bed, an ~20% increase in this behavior since 1998 [1]. In many respects, people have more frequent and close contact with their pets than with most other people.

North American pet owners are spending increasing sums of money on a growing variety of pet products and services [1]. Pet treat manufacturers are making available an expanded range of pet treats. Pig ear treats and other treats made from animal parts, such as bull penises and cow hooves, have become popular as "natural" pet treat alternatives. A relatively new trend in pet food is "biologically appropriate" or raw food diets, as typified by the Bones and Raw Food Diet

(BARF) [2]. Recipes for homemade raw food diets are available from a variety of sources, and commercial versions are available from suppliers, pet stores, and some veterinarians as premade frozen meals consisting of raw meats, grains, and vegetables to be served raw as the animal's main meal. These diets are widely touted by their proponents as being more appropriate than commercial pet foods and as resulting in improved coat quality, health, immune status, and longevity [2]; however, there currently are no objective data that support any of these claims. Raw food diets have become a subject of considerable disagreement among veterinarians and owners of companion animals over the past few years, with respect to their nutritional benefits and the risk that they pose to the health of animals and humans [3–5]. There is no available information on how common the use of a raw food diet is, but it is estimated that ~40% of dog owners purchase natural pet treats 5 times per year, on average [1].

Dogs and cats are potential sources of several zoonotic diseases, including salmonellosis. An emerging concern with respect to *Salmonella* carriage in pets is the role of natural pet treats and raw food diets, which are produced with little to no regulatory oversight in the United States and Canada [6]. Overall, there is a lack of information on how natural pet treats and raw food diets can affect the health of pets and their owners, both in general and with respect to *Salmonella* contamination.

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SALMONELLA SPECIES IN HUMANS

It has been estimated that 1.4 million people are infected with *Salmonella* organisms annually in the United States [7, 8]. The illness is usually self-limiting, but ~15,000 cases of salmonellosis result in hospitalization of the infected individuals, and 500 of the total number of cases are fatal each year [7]. Although ~95% of cases of nontyphoidal salmonellosis in humans are associated with foodborne contamination, an unknown proportion of these cases are the result of contact with infected pets and contaminated pet food products. Sporadic cases, some of which could be caused by pet exposure, usually are not investigated thoroughly or reported to the local health authorities, especially cases that occur in adults. In the United States, it is estimated that 1% of the number of cases of salmonellosis reported annually are associated with contact with companion animals [9].

There have been a limited number of reports of humans with *Salmonella* infection associated with exposure to ill or subclinically affected dogs living in the same household [10–12]. There have also been several recent outbreaks of salmonellosis associated with companion animal veterinary clinics and animal shelters, consisting of the spread of *Salmonella* organisms from cats to humans and other animals [13, 14].

SALMONELLA SPECIES IN DOGS AND CATS

Clinical salmonellosis in dogs is similar to salmonellosis in humans, and symptoms may include fever, malaise, vomiting, abdominal pain, and diarrhea. Cardiovascular collapse and shock can occur, as can systemic infection, generally in pediatric, geriatric, or immunocompromised patients [15]. There is little information on the duration of *Salmonella* colonization in dogs; however, it has been widely quoted that, once infected, a dog can shed *Salmonella* organisms in its feces for ≥ 6 weeks, continuously for the first week and then intermittently [10, 16]. The estimated prevalence of *Salmonella* organisms in normal, healthy dogs is 1%–36% [16], and numerous *Salmonella* serotypes have been identified [17], with *Salmonella* serotype Typhimurium and *Salmonella* serotype Anatum identified most commonly in the United States [18]. A recent study of 188 healthy dogs in southern Ontario, Canada, found that no dogs were colonized with *Salmonella* organisms [19]; however, this finding may, in part, be related to the use of rectal swab specimens instead of fecal samples and/or use of a single sample rather than serial samples. A case-control study of 60 diarrheic and 60 nondiarrheic dogs in northern California similarly found that no dogs were colonized with *Salmonella* organisms, but it also relied on a single fecal sample for culture [20]. Because dogs with *Salmonella* colonization intermittently shed the organisms in feces, studies that have relied on single sam-

ples, particularly low-volume samples collected by rectal swab, may have underestimated the true prevalence of *Salmonella* carriage by dogs.

Sources of *Salmonella* organisms in dogs are various and include consumption of infected rodents and rabbits, coprophagia, and consumption of *Salmonella*-contaminated foods [18, 21]. To date, there have been no published reports of salmonellosis occurring in dogs as a result of exposure to natural pet treats. Anecdotal reports of canine illness were received during the investigation of a human salmonellosis outbreak caused by *Salmonella* serotype Infantis in Canada in 1999 (P. Sockett, unpublished data). Five (11.4%) of 44 dog owners indicated that their dog had been ill during the week before the onset of their own illness and that their dog also had a history of exposure to pig ear treats.

There have been reports of racing sled dogs, racing greyhounds, and guard dogs with *Salmonella* infections due to consumption of contaminated raw meat [22–24]. Commercially available raw food diets are a relatively new product, and there have been no reports associating them with clinical salmonellosis. Fecal shedding of *Salmonella* organisms was evaluated in 20 dogs in Calgary, Alberta, Canada, to determine whether dogs would shed the organism after consumption of homemade raw food diets [25]. *Salmonella* organisms were isolated from 30% of the 10 dogs that were fed homemade raw food diets, but they were isolated from none of the 10 dogs that were fed commercial dry food. None of the dogs exhibited clinical signs of salmonellosis. Of the dogs with *Salmonella* colonization, only 1 had the same serotype (*Salmonella* serotype Schwarzengrund) isolated from both its food and a stool sample [25]. In a similar study conducted in 2004, research beagles were fed commercial raw food diets identified as being contaminated with *Salmonella* organisms. Five of the 7 dogs that shed *Salmonella* organisms after consuming a raw food diet meal shed a *Salmonella* serotype that matched the serotype isolated from the diet that was fed [26]. This study used commercial frozen raw food diets that were naturally contaminated, and clinically healthy dogs became colonized after ingestion of a single meal.

Salmonellosis in cats is similar to salmonellosis in dogs and humans. In addition to exhibiting the usual clinical signs, cats may also experience abortion and demonstrate hypersalivation, conjunctivitis, and chronic febrile illness that can occur without diarrhea [27, 28]. Sources of *Salmonella* organisms in cats are various, but they are dependent on whether cats are indoor or outdoor cats. For indoor cats, the most likely exposure is consumption of food contaminated with *Salmonella* organisms, whereas outdoor cats may be exposed through scavenging and hunting, especially the hunting of birds. The estimated prevalence of *Salmonella* carriage among healthy cats is 1%–18% [27], with a variety of serotypes having been identified in the

United States, including *S. Typhimurium*, *Salmonella* serotype Enteritidis, *S. Anatum*, and *Salmonella* serotype Derby [19].

To date, there has been only one published report of salmonellosis occurring in cats as a result of exposure to raw food diets. Septicemic salmonellosis was diagnosed in 2 cats that underwent necropsy at the College of Veterinary Medicine, University of Georgia (Athens, GA). *Salmonella* serotype Newport was recovered from raw meat that had been fed to both cats, and these isolates were indistinguishable from isolates recovered from the intestines and lungs of one of the animals [29].

SALMONELLA SPECIES IN NATURAL PET TREATS AND RAW FOOD DIETS

Pet treats of animal origin have been associated with human salmonellosis in both Canada and the United States. In 1999, an outbreak of human salmonellosis caused by *S. Infantis* was identified. An increase in the number of cases of infection due to *S. Infantis* was seen across the country, compared with the number of cases seen during the same period in 1998 (P. Sockett, unpublished data). In Alberta, Canada, 9 of 12 case patients with *S. Infantis* infection had been exposed to pig ear treats [6], and *S. Infantis* was isolated from a pig ear treat collected from the household of one of the case patients. The isolate recovered from the pig ear had the same phage type, and, on PFGE, it was indistinguishable from *S. Infantis* isolates recovered from fecal samples obtained from humans with salmonellosis [6]. A nationwide survey was conducted to investigate all laboratory-confirmed cases of *S. Infantis* infection. Thirty-five (41.2%) of all case patients identified reported having been exposed to pig ears before the onset of their illness (P. Sockett, unpublished data). A case-control study showed an OR of 7.9 (95% CI, 1.6–75.5) for exposure to pig ear treats among dog owners.

As part of the investigation of the outbreak, samples of pig ear treats were obtained from retail outlets in the province of Alberta and from several pet treat plants across the country. *Salmonella* organisms were isolated from 48 (51%) of 94 pig ear samples obtained from retail outlets [30]. *Salmonella* organisms were also found in products associated with outbreaks that occurred in 5 (42%) of the 12 pet treat plants visited, whereas 49 (29%) of 171 pig ear treats collected contained *Salmonella* organisms [30]. Nineteen *Salmonella* serotypes were isolated from all sources combined, including *S. Infantis* (18% of isolates from pig ear treats), *S. Typhimurium* (11%), and *S. Derby* (10%).

In 2002, also in Calgary, a smaller outbreak caused by *S. Newport* PT 14 was identified. The index case patient was a 1-month-old infant. Other case patients identified in the outbreak were the sister and father of the index case patient and 2 individuals with no connection to the family of the index case patient. No *Salmonella* isolates were obtained from either the

environmental or pet stool samples obtained from the 3 households affected; however, *S. Newport* PT 14 was isolated from a commercial pet treat obtained from the property of one of the unrelated individuals. All 3 households fed the same pet treat, a dried beef patty imported from Texas. PFGE showed that the strains recovered from the humans and the pet treats were highly related, with 2 of the strains recovered from humans found to be indistinguishable from the strain recovered from the pet treats [31]. There was a third pet treat-associated human outbreak that occurred in 2005; this outbreak was due to *Salmonella* serotype Thompson. Few details were available at the time that this article was written; however, it appears that 5 cases of infection, 3 of which occurred in Canada and 2 of which occurred in the United States, developed among people who handled pet treats from a single manufacturer [32, 33].

As a follow-up to the 1999 outbreak in Canada, the US Food and Drug Administration (FDA) conducted a national survey of animal-derived pet treats in which 158 treats, both domestic and imported, were sampled. Sixty-five treats (41%) were contaminated with *Salmonella* species of 24 different serotypes [34]. The most common serotypes were *S. Anatum* (19% of 78 isolates serotyped), *S. Typhimurium* (14%), *S. Infantis* (10%), *S. Derby* (8%), and *Salmonella* serotype Ohio (8%). A total of 36% of isolates were resistant to at least 1 antimicrobial, whereas 13% were resistant to ≥ 4 antimicrobials.

To date, raw pet foods have not been associated with salmonellosis in humans; however, identification of *Salmonella*-contaminated food and *Salmonella* shedding by pets that have been fed raw food diets should raise concern. A 1993 study of 112 samples of raw meat used in greyhound diets reported recovery of *Salmonella* isolates from 50 samples (44.6%). Of the 13 serotypes isolated, *S. Typhimurium* was identified most frequently (in 48% of samples) [35]. Isolates were resistant to ceftiofur, clindamycin, erythromycin, penicillins, sulfadimethoxine, and tetracycline [35]. In a study of homemade raw food diets that was conducted in Calgary, *Salmonella* species were isolated from 8 (80%) of 10 samples. Three different serotypes (*Salmonella* serotype Braenderup, *Salmonella* serotype Hadar, and *S. Schwanzengrund*) were identified [25]. In 2 recent surveys of commercial, frozen raw food diets, the first of which was conducted in southern Ontario and the second of which was conducted in southern Ontario and Calgary, 5 (20%) of 25 samples and 35 (21%) of 166 samples, respectively, were contaminated with *Salmonella* species [26, 36]. The susceptibility patterns observed were similar to those that the Canadian Integrated Program for Antimicrobial Resistance Surveillance reported for chicken meat, which is the principal component of the majority of *Salmonella*-contaminated commercial raw food diets for which samples have been available. Similar results were observed by researchers in Fort Collins, Colorado, who

isolated *Salmonella* species in 10 (48%) of 21 samples of commercial raw food diets sampled [37].

PET FOOD REGULATIONS AND GUIDELINES

Food regulatory agencies provide specific guidelines on the manufacture and labeling of food; processing plants need to follow these guidelines to guarantee the integrity and quality of the food being produced for consumption by humans, to reduce or limit the risk of illness or death posed by food products. Although natural pet treats and raw food diets are made from animal by-products, they are not considered to be “fit for human consumption,” and, as such, they are not subject to the same regulations as is food intended for humans. No federal human agency in the United States or Canada oversees or regulates the market, other than to provide guidance regarding ingredients, labeling, health claims, and permits required for the production and importation of pet food [38, 39].

In the United States, 2 sets of guidelines have recently been created, 1 for the manufacturing of natural pet treats and 1 for the manufacturing and labeling of raw meat foods for companion animals. The *Guidelines for the Manufacturing of Natural Pet Treats for Pets* [40] have been reviewed by members of the American Pet Product Manufacturers Association, as well as by the FDA, and adherence to these guidelines is completely voluntary. The main purpose of the guidelines is to promote and advance the manufacturing of uncontaminated pet treat products. The document *Guidance for Industry: Manufacture and Labelling of Raw Meat Foods for Companion and Captive Non-Companion Carnivores and Omnivores* [41] was created to provide to the industry more-specific guidance on how such products should be manufactured and labeled so that pet owners and pets may be protected from risks involving food safety.

CONCLUSIONS

The risk to human health posed by the handling and feeding of pet treats and raw food diets remains unquantified, although data are accumulating to the point that formal quantified risk assessment may be possible and well-designed epidemiologic studies may be conducted. Factors contributing to the lack of information include the ability of dogs and cats to shed *Salmonella* species without exhibiting clinical signs of illness, the underreporting of health risks by those in human medicine or companion animal veterinary medicine, and the limited information regarding risk factors for *Salmonella* infection in companion animals. Underreporting of the prevalence of *Salmonella* colonization and salmonellosis in dogs and cats is principally a consequence of the cost to pet owners of culture and susceptibility testing, as well as the lack of a formal system for collecting data on zoonoses in companion animals.

Dog and cat owners should be made more aware of the zoonotic risks, including salmonellosis, that are associated with

diarrheic illness and asymptomatic carriage in dogs and cats and, also, of the potential risks associated with natural pet treats and raw food diets. Owners of animals receiving natural pet treats and raw food diets should be educated about safe handling of their pet and pet feces, cleaning and disinfection of contaminated areas in the household, restriction of contact with humans who might be at higher risk for developing disease (i.e., immunocompromised, antimicrobial-treated, very young, and elderly populations), and appropriate hand hygiene. Of issue is the potential introduction of antimicrobial-resistant pathogens into the community through contaminated natural pet food products, which could contribute to (1) the failure of treatments for *Salmonella* infections or other bacterial diseases that require antimicrobial therapy, or (2) an increase in the number and severity of these infections. Dogs that are used for socialization and therapy at hospitals and long-term care facilities also should not be exposed to raw food diets, pig ear treats, and other pet treats made of dried animal parts, unless it is clear that the products used are pathogen free. It is possible that dogs used for socialization and therapy purposes could carry *Salmonella* organisms with resistance to various antimicrobials, including third-generation cephalosporins, which could interfere with other treatments that the patients and senior citizens at hospitals and long-term care facilities might require. Further study of the incidence of salmonellosis and the prevalence of *Salmonella* carriage in dogs and cats should be undertaken, as should analysis of the associated risk factors.

We have observed the frequent absence of labels or educational materials included in the packaging or available at the point of sale of pet treats made of dried animal parts and commercial raw food diets. In some instances, natural pet treats are sold in bulk bins without any packaging material or instructions available to buyers regarding the hygienic procedures to follow after handling the products. Depending on the level of hygiene practices followed, pet owners could contaminate cooking utensils when preparing the pet's meal. Feeding areas could also be contaminated and could represent a source of exposure. This could lead to illness developing in members of the household, especially children and immunocompromised persons. Children could also have direct contact with pet treats if the treats are not stored in a secure location. The risk posed by these products is not limited to household members, because some dogs and cats are used for therapeutic visits to hospitals and long-term care facilities for senior citizens. Objective evidence of the risk of zoonotic transmission of *Salmonella* organisms by dogs and cats used for therapeutic visits is currently lacking. However, considering that many hospitalized humans are presumably more susceptible to infection, it is reasonable to require that such pets not be fed natural pet treats or raw food diets.

Recognizing that a percentage of cases of salmonellosis in

North America are sporadic, physicians and public health officials should make further inquiries regarding those cases that developed without an obvious source of exposure and, in particular, those that developed when dogs or cats were present in the household. Investigators should consider asking about the products that owners feed their pets, in particular pet treats and raw foods. Environmental samples should be collected from the animal's feeding area, along with stool samples, and they should be tested for the presence of *Salmonella* organisms, even if the animals appear to be healthy. Stool sample collection and testing should be repeated for several days, because pets may be transiently colonized and may continue to be a vehicle for the spread of infection over a period of time. Overall, pet owners can reduce the risk of their pets acquiring *Salmonella* infection, as well as the risk of acquiring human salmonellosis, by not feeding natural pet treats and raw food diets to their pets that have not been cleared for bacterial contamination.

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