Human *Salmonella* Infections Linked to Contaminated Dry Dog and Cat Food, 2006–2008
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Human *Salmonella* Infections Linked to Contaminated Dry Dog and Cat Food, 2006–2008

**WHAT'S KNOWN ON THIS SUBJECT:** Because pet foods and treats contain foods of animal origin, these items are at risk for *Salmonella* contamination. Human salmonellosis had not been previously linked to dry dog and cat foods.

**WHAT THIS STUDY ADDS:** This investigation resulted in identification of the first documented outbreak of human salmonellosis linked to the use of dry dog and cat food. Dry pet food may be contaminated with *Salmonella* and could be an underrecognized source of human infections, especially in young children.

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**ABSTRACT**

**OBJECTIVE:** Human *Salmonella* infections associated with dry pet food have not been previously reported. We investigated such an outbreak of *Salmonella* Schwarzengrund and primarily affecting young children.

**PATIENTS AND METHODS:** Two multistate case-control studies were conducted to determine the source and mode of infections among case-patients with the outbreak strain. Study 1 evaluated household exposures to animals and pet foods, and study 2 examined risk factors for transmission among infant case-patients. Environmental investigations were conducted.

**RESULTS:** Seventy-nine case-patients in 21 states were identified; 48% were children aged 2 years or younger. Case-households were significantly more likely than control households to report dog contact (matched odds ratio [mOR]: 3.6) and to have recently purchased manufacturer X brand of dry pet food (mOR: 6.9). Illness among infant case-patients was significantly associated with feeding pets in the kitchen (OR: 4.4). The outbreak strain was isolated from opened bags of dry dog food produced at plant X, fecal specimens from dogs that ate manufacturer X dry dog food, and an environmental sample and unopened bags of dog and cat foods from plant X. More than 23 000 tons of pet foods were recalled. After additional outbreak-linked illnesses were identified during 2008, the company recalled 105 brands of dry pet food and permanently closed plant X.

**CONCLUSIONS:** Dry dog and cat foods manufactured at plant X were linked to human illness for a 3-year period. This outbreak highlights the importance of proper handling and storage of pet foods in the home to prevent human illness, especially among young children. *Pediatrics* 2010;126:477–483

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**KEY WORDS**

*Salmonella*, pet food, children, pets, dog, cat, zoonoses, outbreak

**ABBREVIATIONS**

PFGE—pulsed-field gel electrophoresis

PADOH—Pennsylvania Department of Health

CDC—Centers for Disease Control and Prevention

FDA—Food and Drug Administration

OR—odds ratio

mOR—matched odds ratio

CI—confidence interval

MLE—maximum likelihood estimate

MUE—median unbiased estimate

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Salmonella enterica causes an estimated 1.4 million illnesses and 400 deaths annually in the United States.\textsuperscript{1} Salmonella bacteria are found in the intestinal tract of animals, and the majority of human infections are acquired by consumption of contaminated food products, particularly foods of animal origin. Infections also are acquired by direct and indirect contact with animals.\textsuperscript{2-4} Forty-three million US households (37%) own dogs and 37.5 million (32%) own cats, and many pet owners feed the animals dry pet food.\textsuperscript{5} Concerns about the safety of pet foods have increased in recent years.\textsuperscript{6} Because pet foods and treats contain foods of animal origin, these items are at risk for Salmonella contamination. The S enterica serotype Schwarzengrund is uncommon, causing, on average, 0.4% of all reported laboratory-confirmed human Salmonella infections each year. We investigated a multistate outbreak of human Salmonella Schwarzengrund infections that occurred during a 3-year period.

PATIENTS AND METHODS

Outbreak Identification and Case Finding

State diagnostic laboratories forward Salmonella strains from clinical samples to state public health laboratories for characterization analyses including serotyping and pulsed-field gel electrophoresis (PFGE). PFGE patterns are electronically submitted to PulseNet, the national molecular subtyping network for foodborne disease surveillance.\textsuperscript{7} In 2007, PulseNet identified a multistate outbreak of Salmonella Schwarzengrund infections. For this investigation, a case was defined as a person who resided in the United States and became ill between January 1, 2006, and October 31, 2008, and whose culture results yielded Salmonella Schwarzengrund with PFGE Xbol pattern JM6X01.0015 (the outbreak strain).

Laboratory and Environmental Investigation

Investigators from the Pennsylvania Department of Health (PADOH), Ohio Department of Health, Centers for Disease Control and Prevention (CDC), and US Food and Drug Administration (FDA) participated in the laboratory and environmental investigations. Throughout the investigation, personnel from the PADOH and local health departments in Ohio visited patient households to collect samples of dog stool and dog food, and the samples were examined for Salmonella. PADOH staff visited plant X and collected swabs of environmental surfaces with the cooperation of the manufacturer. FDA investigators inspected plant X and collected samples of unopened dry dog and cat food.

Case-Control Studies

Two multistate case-control studies were conducted to determine the source and mode of infections. The objective of the first study was to identify specific exposures to dogs, brands of dry pet foods, or both, that might be associated with infections. The second study examined possible risk factors related to transmission within households with laboratory-confirmed cases in Pennsylvania children aged 2 years or younger.

The first case-control study included patients of all ages with laboratory-confirmed infections with the outbreak strain and with illness onset or isolation dates between January 1, 2006, and August 30, 2007. The analysis for this study was conducted at the household level to compare factors in households with a case-patient (case-household) to households with no ill persons (control households). Up to 3 geographically matched control households were recruited for each case-household.

For the second case-control study, at least 2 control subjects were recruited for each case-patient based on geographic location. The control group was restricted to children aged 2 years or younger and children who had regular dog contact, either in the home or at another location. Children who were potential controls were selected from a randomly generated list that included Pennsylvania households with an infant born between July 1, 2005, and July 20, 2007, and excluded infants who were adopted or deceased.

For both studies, a structured questionnaire was developed to collect data from study participants on contact with animals that might eat dry dog or cat food, brand information for purchased dry pet food, handling and storage of dry pet food, and pet-feeding practices. During the interview, respondents were encouraged to seek assistance from other household members in answering questions and were asked to provide identification information (eg, brand, lot number) from the most recently used dry pet food bag, if still available. Primary caregivers were interviewed for children aged 17 years or younger.

Statistical Analysis

Data from the case and control questionnaires were entered into a Microsoft Access 2000 database (Microsoft Corp, Redmond, WA). Statistical analyses were conducted using SAS 9.1 (SAS Institute, Cary, NC). Odds ratios (ORs) and matched odds ratios (mORs) and 95% confidence intervals (CIs) were calculated to examine relationships between each exposure and disease. Because manufacturers produce a variety of brands of dry dog and cat food, data from responses to ques-
tions about dry dog and cat food brands usually purchased and those recently purchased were combined to produce a synthetic variable to analyze likely exposure to a dry dog or cat food according to manufacturer. Bivariate and multivariate analyses were performed. We report maximum likelihood estimates (MLEs) of ORs by default. Median unbiased estimates (MUEs) are reported when MLEs do not exist.

RESULTS

Outbreak Identification and Case Finding
Seventy-nine ill persons infected with the outbreak strain were reported to the CDC from 21 states during a 3-year period (Fig 1). Forty-eight percent (32 of 67) ill persons were children aged 2 years or younger; 58% (39 of 67) were female. No deaths were reported.

In 2006, the PADOH identified a small cluster of *Salmonella* Schwarzengrund infections, but early investigations did not identify the source (Fig 2). When cases reappeared in May 2007, results of hypothesis-generating interviews suggested exposure to dogs as a possible source of infections. Focused interviews with individuals associated with 8 cases that occurred in Pennsylvania residents suggested exposure to dogs, dry dog food, or both as possible sources of infections. However, no dog food brand was named in association with more than 2 cases, and no database was available to facilitate identification of brands made by a common plant.

Laboratory and Environmental Investigation
In 2007, the outbreak strain was isolated from 38% (5 of 13) dog fecal specimens and 9% (2 of 22) dry dog food specimens collected from 9 Pennsylvania case-households. The bags of dry dog food found to be contaminated were 2 brands (brands A and B), both produced by manufacturer X at the same Pennsylvania facility (plant X), as identified by the production code on each bag. In July 2007, Ohio epidemiologists interviewed patients or caregivers of patients infected with the outbreak strain and collected 2 dog fecal specimens from 1 patient’s home. The outbreak strain was isolated from 1 of these specimens. The dog had been fed brand A dry dog food, but the bag was no longer available to determine the plant of origin.

On the basis of these findings, environmental samples were obtained from plant X. The outbreak strain was isolated from 1 of 144 plant X swab samples. The positive swab was taken from the enrobing/flavoring room, where material was sprayed onto the surface of the fin-
sished product to enhance palatability before bagging.

In August 2007, the FDA reported that the outbreak strain had been identified in unopened bags of 2 brands of dry dog food (brand E and brand F) produced at plant X. After additional cases of *Salmonella* infection were found in mid-2008, the FDA conducted additional sampling of unopened bags of dog food in August 2008. Multiple samples from 8 available brands of dry dog and cat food and multiple sub-samples from 8 raw materials used in the production of dry pet food were tested for *Salmonella*. The outbreak strain of *Salmonella* Schwarzengrund was found by the FDA in 4 samples of unopened pet foods: 2 dry dog food brands (brand E and brand K) and 2 samples of 1 brand of dry cat food (brand C) produced at plant X. No other *Salmonella* serotypes were identified in samples from patient households or plant X.

### Case-Control Studies

For the first case-control study, persons in 43 case-households and 148 control households from 8 states were interviewed. Among the ill persons, the median age was 3 years (range: 1 month to 85 years); 44% (19 of 43) ill persons were aged 2 years or younger, and 51% (22 of 43) were female. Symptoms reported by the 43 ill persons included bloody diarrhea in 15 (39%) patients and fever in 26 (60%). Eleven of the case-patients were hospitalized (median: 4 days; range: 1–14 nights). The median age of the control individuals was 24.5 years (range: 0–89 years); 69% (93 of 135) of the controls were female.

Illness in a household was significantly associated with contact with a dog (mOR: 3.6; 95% CI: 1.1–15.6) (Table 1). Members of a case-household were significantly more likely than members of control households to have recently purchased dry dog food, dry cat food, or both produced by manufacturer X (mOR: 9.2 [95% CI: 1.6–93.9]). One brand (brand Z) produced by manufacturer Z was also found to be more likely to be usually purchased by case-households (12% of case-households compared with 2% of control households, mOR (MUE): 33.1 [95% CI: 4.3 to ∞]). However, case-households were as likely as control households to usually purchase any brand of dry dog food produced by manufacturer Z (mOR: 0.5 [95% CI: 0.2–1.4]).

When analysis was restricted to only households in Pennsylvania (n = 24), the location of plant X, associations seemed stronger. Illness was associated with contact with a dog (mOR (MUE): 14.4 [95% CI: 2.3 to ∞]), with recent purchase of a brand of dry pet food produced by manufacturer X (mOR: 11.9 [95% CI: 3.1–68.4]), and purchase of brand A produced by manufacturer X (mOR: 9.2 [95% CI: 1.6–93.9]). One brand (brand Z) produced by manufacturer Z was also found to be more likely to be usually purchased by Pennsylvania case-households (13% of case-households compared with 1% of control households, mOR (MUE): 24.0 [95% CI: 2.5 to ∞]). No other manufacturer Z brands were associated with illness in Pennsylvania.

For the second case-control study, 18 ill children aged 2 years or younger were included along with 45 birth-registry controls. The mean age of case-patients was 0.98 years (range: 1 month to 2 years); 56% (10 of 18) patients were female. The mean age of control children was 1 year (range: 0–2 years); 48% (19 of 40) controls were female. Illness was significantly associated with cases in which the child fed a pet in the kitchen (OR: 4.4 [95% CI: 1.2–15.4]), the primary caregiver had contact with pet treats (OR: 4.3 [95% CI: 1.2–15.4]), and the child attended day care (OR: 3.8 [95% CI: 1.2–11.9]) (Table 2). A multivariate analysis did not yield significant results.

### TABLE 1 Bivariate Analysis of Pet-Related Exposures Among Case-Patients With *Salmonella* Schwarzengrund Infection and Controls

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Patients, n/N (%)</th>
<th>Controls, n/N (%)</th>
<th>Matched, Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contact with any animal that might eat dry pet food</td>
<td>37/42 (88)</td>
<td>119/146 (82)</td>
<td>2.4 (0.6 to 13.7)</td>
</tr>
<tr>
<td>Dog contact</td>
<td>34/43 (79)</td>
<td>100/147 (68)</td>
<td>3.6 (1.1 to 15.6)</td>
</tr>
<tr>
<td>Sleeps in bed with dog</td>
<td>13/41 (32)</td>
<td>33/147 (22)</td>
<td>1.6 (0.6 to 4.1)</td>
</tr>
<tr>
<td>Household purchases pet food</td>
<td>34/43 (79)</td>
<td>105/146 (72)</td>
<td>2.4 (0.8 to 8.8)</td>
</tr>
<tr>
<td>Household purchases dry pet food</td>
<td>32/42 (76)</td>
<td>103/146 (71)</td>
<td>2.0 (0.7 to 6.4)</td>
</tr>
<tr>
<td>Manufacturer X product typically used</td>
<td>18/43 (42)</td>
<td>18/148 (12)</td>
<td>5.7 (1.9 to 19.0)</td>
</tr>
<tr>
<td>Manufacturer X product recently used</td>
<td>17/43 (40)</td>
<td>17/148 (11)</td>
<td>6.9 (2.2 to 25.7)</td>
</tr>
<tr>
<td>Brand A produced by manufacturer X typically used</td>
<td>11/43 (26)</td>
<td>10/148 (7)</td>
<td>7.1 (1.6 to 42.9)</td>
</tr>
<tr>
<td>Manufacturer Z products usually used</td>
<td>8/43 (19)</td>
<td>49/148 (33)</td>
<td>0.5 (0.2 to 1.4)</td>
</tr>
</tbody>
</table>

Interviews were conducted among residents of Delaware, Maine, Michigan, Minnesota, North Dakota, New York, Ohio, and Pennsylvania.

* Case and control households were excluded from analysis for instances in which questions were not answered.

* Case-households within 2 weeks of illness onset; control households within 2 weeks of interview.

* MUE.
Plant X

Dry pet foods are manufactured by mixing various raw ingredients, eg, corn, rice, and meat byproducts. Next, these ingredients are heated and then extruded under high pressure through a device with specific plates to obtain the shape and size of the specific product. At plant X this process included a device with specific plates to obtain the product.

A case-control study was conducted to determine why human illness, especially among infants, was associated with dry pet food. This study found that illness was associated with feeding pets in the kitchen. This finding suggests that cross-contamination in the kitchen is an important source of human illness. No association was found between illness and children placing pet food in their mouths. For this study, it should be noted that simple ORs were reported, and the power to detect differences in this study was limited because only 18 case-patients were available for inclusion.

A low attack rate supports the hypothesis that infection might have resulted from practices in a limited number of households. One possibility is that the number of organisms was magnified in some households because of eg, cross contamination in the kitchen or irregular cleaning of pet food bowls, which might promote bacteria growth. In addition, illness may have occurred primarily in persons who were more susceptible to infection with a small number of organisms. Illness was not reported in dogs or cats from case-patient households, although the outbreak strain was cultured from several stool specimens from dogs who ate contaminated dry dog food. Some children may have become ill from contact with a pet carrying the outbreak strain. Prevalence of isolation of Salmonella from feces of healthy dogs is reported to be between 1% and 36%, and from healthy cats between 1% and 18%. Dogs and cats may shed Salmonella in the feces for as long as 12 weeks, and shedding may be intermittent, so the risk of infection could continue for extended periods.

Two recalls of dry pet food were issued in response to this outbreak. Dry pet food has an extended shelf life or sell-by date. In addition, it is thought that Salmonella can survive for extended periods in dry dog and cat food, as it can in similar dried foods such as cereals. Therefore, contaminated products that may remain in house-
holds even after recalls can potentially lead to additional human illness. Because a limited number of Salmonella infections are confirmed by laboratory results and are reported to public health surveillance systems, this outbreak was likely much larger than the 79 laboratory-confirmed cases identified.

Millions of US households own dogs and cats, and dry pet food, the most common pet food fed to dogs and cats, is not manufactured to be a sterile product. Typically, a more drastic heat treatment is required to destroy Salmonella in dried food products. Plant X’s process included time and temperature conditions validated to kill Salmonella, and FDA inspectors had no indication that these conditions were not met during plant X inspections. We suspect that dry pet food was recontaminated after the kill step, because the outbreak strain was detected in the plant X enrobing/flavoring room, where material was sprayed onto the surface of the finished product to enhance palatability. Studies to assess the prevalence of Salmonella contamination in dry pet food should be conducted.

Human illness had not been previously linked to dry pet foods. Salmonella contamination has not been identified in canned pet food, probably because the manufacturing process eliminates contamination. However, human illness has been associated with animal-derived pet treats. In 1999–2000 in the United States, Salmonella was isolated from 65 (41%) of 158 samples of pig ears and other animal-derived pet treats purchased from retail stores. In addition, Salmonella contamination has been frequently identified in raw pet food diets containing animal protein, which suggests that raw pet food diets put human handlers and animals at risk for salmonellosis. Pet foods, treats, and supplements are regulated by the FDA. If Salmonella is present in finished products, these products are considered adulterated under the Federal Food, Drug, and Cosmetic Act, which requires that pet foods, like human foods, be pure and wholesome, safe to eat, and produced under sanitary conditions; contain no harmful substances; and be truthfully labeled (www.fda.gov/opacom/laws/fdca/fdca4.htm). Since 2006, according to the FDA, at least 13 recall announcements involving 135 pet products (eg, dry dog food and cat food, pet treats, raw diets, and pet supplements) have been issued because of Salmonella contamination. Multiple Salmonella serotypes have been associated with recalls issued because of contamination, and recalls have been associated with multiple plants in the United States that manufacture pet food. Pet products typically are recalled after product testing indicates Salmonella contamination. No human illness was associated with these other pet food recalls.

Although interactions with pets and other animals have many benefits, infectious diseases such as salmonellosis may be associated with these interactions. Pediatricians, veterinarians, and other health care professionals can play important roles in guiding families on ways to reduce the risk of infections involving animals and animal products. Pediatricians have unique opportunities to offer information and advice to parents and children during well-child visits. A history of contact with pets or other animals should be part of every well-child evaluation and especially evaluations of suspected infectious diseases. Pediatricians and other health care professionals should counsel patients and their families on sources of salmonellosis that commonly affect young children, eg, farm animals, live poultry, reptiles, amphibians, rodents, and ill animals. Both direct contact with animals and indirect contact with environments where animals live and roam and other materials associated with animals (eg, tank water, food and water dishes, and cages) can lead to human infections. In addition, other known risk factors include handling pet treats, visiting petting zoos, and riding in shopping carts next to meat and poultry. The outbreak reported here highlights the additional risk factor of direct or indirect contact with contaminated dry dog and cat food. The recommendation to wash hands is the most important prevention step for reducing the risk for disease transmission. Pet food bowls and pet feeding areas should be routinely cleaned and disinfected. Infants should not have access to pet feeding areas. Children aged <5 years should not be allowed to touch or eat pet food, treats, or supplements and should be kept away from pet feeding areas. Animal housing, food or water dishes, and other materials associated with animals should not be cleaned in kitchen sinks or bathtubs. Infants should not be bathed in kitchen sinks because of the risk of cross contamination. Parents can be made aware of Web sites that provide guidelines for safe animal interactions such as the CDC’s Healthy Pets Healthy People (www.cdc.gov/healhyypets). In addition, educational brochures and posters can be made available in medical offices.

**CONCLUSIONS**

This investigation resulted in identification of the first documented outbreak of human illness linked to household use of dry dog and cat food, which included multiple brands produced at a single plant. Dry dog and cat foods manufactured at plant X were linked to human illness, primarily among young children, during a 3-year period. This investigation demonstrated that dry pet food may be contaminated with Salmonella and raises concerns that such contamination could be an un-
The recognition of Salmonella as a leading cause of zoonotic infections, especially in young children, highlights the importance of proper handling and storage of pet foods in the home to prevent human illness, especially among young children. Consumers and health care professionals, including pediatricians, veterinarians, and health-department personnel, should be aware that any dry pet food, pet treats, and pet supplements might be contaminated with pathogens such as Salmonella.

**Salmonella Schwarzengrund Outbreak Investigation Team**

The members of the Salmonella Schwarzengrund Outbreak Investigation Team are Carol Teacher and Perry Fox (Pennsylvania Department of Health); Eric Brandt, Steven York, Katherine Grandfield, Rebekah Carman, Lai Ming Woo, Rick Bokanyi, and Christina Allman (Ohio Department of Health); and Sarah Alexander (Centers for Disease Control and Prevention).

**REFERENCES**


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