
Christina K. Ahn, BS, Anthony J. Russo, MPH, Karla R. Howell, RN, Nicholas J. Holt, BS, Patricia L. Sellenriek, BS, MBA, Robert J. Rothbaum, MD, Anne M. Beck, MD, Leon J. Luebbering, BS, and Phillip I. Tarr, MD

Five Missouri patients infected with \textit{Escherichia coli} O157:H7 were studied for an epidemiologically plausible association. Case isolates, case interviews, and pathogen and meat \textit{XbaI} pulsed field electrophoresis patterns were consistent with the common source being contaminated, fermented deer sausage, a previously unrecognized mode of transmission for \textit{Escherichia coli} O157:H7. (\textit{J Pediatr} 2009;155:587-9)

\textit{Escherichia coli} (\textit{E. coli}) O157:H7 is an important human pathogen. Approximately 4500 cases of culture proven \textit{E. coli} O157:H7 occur annually in the United States according to the CDC.\textsuperscript{1} Cattle are an oft-implicated source, but many additional vehicles have been identified.\textsuperscript{2,3} One uncommon source is deer meat. Deer excrete \textit{E. coli} O157:H7 in their feces.\textsuperscript{4-6} The first outbreak associated with deer meat was recognized in Oregon in 1995.\textsuperscript{5} Here, we report an \textit{E. coli} O157:H7 cluster caused by contaminated deer sausage, a novel vehicle.

\textbf{Methods}

A time-space cluster of 4 people with probable or definite \textit{E. coli} O157:H7 infection was identified by St Louis Children’s Hospital (SLCH) physicians on October 19 and 20, 2007.

\textbf{Case Definitions}

A definite case was a patient with diarrhea, whose stool culture yielded \textit{E. coli} O157:H7. A probable case was a patient with postdiarrheal hemolytic uremic syndrome (HUS) but negative stool cultures. HUS is defined as hemolytic anemia (hematocrit <30% with evidence of intravascular erythrocyte destruction on smear), thrombocytopenia (platelet count <150 000 mm\textsuperscript{-3}), and renal insufficiency (creatinine > upper limit of normal for age). Patient 2, as the first recognized patient in the cluster, was considered the index case.

\textbf{Diagnostic Microbiology Tests}

Stool specimens were cultured for isolation of routine bacterial pathogens, including \textit{E. coli} O157:H7, using sorbitol MacConkey (SMAC) agar. Shiga toxin (Stx) enzyme immunoassay (EIA) (Meridian Bioscience, Cincinnati, Ohio) was used to identify Stx in broth cultures of stools. A presumptively positive isolate was a sorbitol colorless colony on SMAC agar that reacted with an agglutination reagent (Oxoid, Cambridge, United Kingdom) and did not react with a latex-only reagent. These isolates were then sent to the Missouri State Public Health Laboratory for confirmation.

\textbf{Case Reports}

On September 28, patient 1, a 5 year old girl, presented to the SLCH Emergency Unit with bloody diarrhea after 1 day of abdominal pain, nonbloody diarrhea, and vomiting. On day 8 of illness, she met criteria for HUS. She received 3 erythrocyte transfusions, parenteral nutrition, and 24 days of peritoneal dialysis. She was discharged home 36 days after admission. Stool from the day of admission yielded \textit{E. coli} O157:H7 2 days later.

On October 19, patient 2 (index case), a 3 year-old-girl, was evaluated in a suburban hospital after 3 days of diarrhea and 1 day of bloody diarrhea. A stool culture was obtained, and she was sent home. Her family brought her to SLCH late on day 5 of illness for continuing abdominal pain. Three days later she met the case definition of HUS. She underwent 31 days of peritoneal dialysis and received 1 erythrocyte transfusion. Stool cultures and Stx EIA
d from day 5 of illness did not yield \textit{E. coli} O157:H7 at either SLCH or the suburban hospital.

On October 20, patient 3, patient 2’s 6-year-old sister, was admitted to SLCH on day 4 of diarrhea, vomiting, and abdominal pain. She was discharged 4 days later without development of HUS or bloody diarrhea. Stool from day 4 of illness was presumptively positive for \textit{E. coli} O157:H7 1 day later.

On October 20, patient 4, the 33-year-old father of patients 2 and 3, presented to a suburban hospital with abdominal pain, cramping, and nonbloody diarrhea. His stool culture
yielded presumptive *E. coli* O157:H7 2 days later. He did not have HUS.

On October 20, patient 5, a 9-year-old neighbor of patients 2 through 4, presented to the SLCH Emergency Unit with a 2-day history of diarrhea that turned bloody on the day of presentation, and was admitted. She was discharged 6 days later without development of HUS. Stool from day 3 of illness yielded *E. coli* O157:H7 on day 5 of illness. Stx assays on stool broth culture for patients 1, 3, and 5 also were positive (Figure).

**Figure.** Clinical and epidemiologic timeline. Timelines for patients 1 through 5 are portrayed from exposure to symptoms to diagnosis.

### Food Investigation and Bacterial Characterizations

On October 22, epidemiologically incriminated food vehicles were inoculated onto tellurite-cefixime-SMAC agar (TC-SMAC) (Dynal Inc, Lake Success, New York). *E. coli* O157:H7 specimens from patients and from the meat were subjected to pulsed field gel electrophoresis (PFGE) using *XbaI*, and genotyped for *stx1*, *stx2*, bacteriophage insertion sites.

**Results**

### Epidemiologic Investigations

Patient 1’s mother’s extensive food history at the time of her illness provided to the Jefferson County Health Department (JCHD) did not mention deer sausage. The case was considered to be sporadic, with no identified source.

SLCH physicians contacted the Saint Louis County Department of Health (STLCODOH) on October 20, based on the clinical profile of cases 2 and 3. STLCODOH investigators customarily interview patients with possible foodborne infections at SLCH. A STLCODOH investigator determined that a common exposure could be deer sausage produced by an unlicensed, uninspected in-home processor in Jefferson County.

### Food Investigation and Characteristics of Isolates

Samples of deer sausage obtained on October 22 and November 5 from the patients’ homes and from the processor yielded presumptive *E. coli* O157 on October 26 and November 9, respectively, which were subsequently confirmed to express the H7 flagellar antigen. These isolates and the 4 patient isolates were all in genotype Cluster 1 and had identical Xba1-PFGE patterns.

### Environmental Investigation

JCHD inspection of the processing facility identified deficient sanitation and refrigeration. Its owner indicated he processed deer products for the Missouri Department of Conservation Share the Harvest Program, where hunters donate game to processors who process, package, and store the product until it can be distributed to low-income Missourians. JCHD compelled the processor to immediately cease operations. JCHD notified food pantries, which then removed remaining incriminated product and contacted recipient families, requesting destruction of suspected meat.

At a follow-up inspection at the processing facility by JCHD and Missouri Department of Agriculture, the owner reported that he also produced cold smoked deer meat sticks, which he traded for leftover raw meat from customers, and named several families (including those of patients 2 through 5) as having received smoked deer sausage sticks. JCHD contacted the recipients, but only 1 had diarrhea. Deer sticks in her household contained *E. coli* O157:H7 with the same PFGE pattern as the outbreak strain, but her stool tested negative for this pathogen.

While visiting a recipient of the meat, investigators noticed a welcome home banner for patient 1 on a neighbor’s house. They then re-interviewed her family and determined that she, too, received deer sausage from her neighbor before she became ill. Her isolate’s PFGE pattern was identical to those described above.

### Discussion

This outbreak has multiple lessons. First, negative cultures do not prove absence of *E. coli* O157:H7 in patients with bloody diarrhea. Fecal cultures and toxin assays for patient 2 were negative on 4 different determinations early in the illness, but cultures from her father, sister, and friend yielded this pathogen.

Second, disease investigation authorities should be contacted if there is clinical suspicion of an *E. coli* O157:H7 cluster to initiate investigation and prevent subsequent cases. Within 6 days of notification, deer sausage was incriminated epidemiologically and further dissemination ceased, including distribution through a social service organization. The identification of this cluster relied on many factors, but the most critical were clinical profiling of the index patient, timely (on a weekend) report to and response of the health department, and recovery of the pathogen.

Third, it is critical to note that protocols in microbiology laboratories that include screening for *E. coli* O157:H7 on all stool specimens hastened the investigation. A suspected isolate was ready for molecular analysis within 48 hours after...
the initial notification of county epidemiologists. We believe protocols that perform Stx ELAs in lieu of inoculating specimens onto SMAC agar to screen for this pathogen are misguided. Forsaking plating delays, and in some situations could thwart, timely investigations.2,9

Fourth, this outbreak introduces deer sausage as a new vehicle for transmission of E. coli O157:H7. Cattle are the best known reservoirs of E. coli O157:H7, but this pathogen has been identified in the feces of other animals.10 Prevalence of E. coli O157:H7 in 338 hunter-harvested white-tailed deer (Odocoileus virginianus) was 0.3% in Louisiana.1 Further, 0.25% to 2.4% of wild white-tailed Nebraska and Kansas deer excrete this pathogen.6,11 An E. coli O157:H7 outbreak caused by unpasteurized apple juice suggested deer feces as a mode of contamination.12 Deer jerky caused 11 confirmed or presumptive cases of E. coli O157:H7.7 A case report suggested that a 7-year-old boy’s infection was caused by consuming undercooked deer steak.13 It is not known to what extent cervids other than white-tailed deer, such as moose, elk, and caribou, carry E. coli O157:H7, but deer sausage should be added to the growing list of transmitting vehicles. The causes of sporadic cases of bacterial enteric infections might be even broader.14

Finally, uncooked sausages, including salamis, present particular challenges to food safety, because consumers assume they are safe to eat as is, because salt, nitrates, and smoke added during processing inhibit or kill many pathogens.15 However, E. coli O157:H7 is unusually resistant to this process because of its stability in acidic environments, and infection can occur with only a few organisms.16 Beef salami and mettwurst, a German raw pork sausage, have transmitted Shiga toxin–producing E. coli O157:H7 and 111,17,18 respectively. Regulations to diminish risk from salami have been promulgated.19 There have been few salami-related outbreaks in recent years. However, very small operations might not have sufficient resources to apply Hazard Analysis and Critical Control Point measures, which industry uses to diminish pathogen risk. Consumers, including recipients of state-sponsored food distribution programs, should be aware of the potential hazards of such foods.

We gratefully acknowledge the work of the Environmental Bacteriology Unit at the Missouri State Public Health Laboratory for their help in isolating the E. coli O157:H7 from the deer sausage.

References