TN23-037: Outbreak Report

Shiga Toxin-Producing *Escherichia coli* O157:H7 (STEC) Outbreak Associated with Attendance at an Animal Exhibit—Tennessee, September–October 2023

Summary

On October 3, 2023, the Tennessee Department of Health (TDH) Northeast Regional Office was notified of two cases of Shiga toxin-producing *Escherichia coli* (STEC). Over the next two weeks a total of nine patients with STEC infections were reported, seven (78%) were hospitalized, and four (44%) developed hemolytic uremic syndrome (HUS), a type of kidney failure. TDH initiated an outbreak investigation in collaboration with colleagues from the Sullivan County Regional Health Department and the state Foodborne and Enteric Disease program. All patients, or their parents, were interviewed with a standardized case report form specific for STEC infections. Questions about exposures known to be associated with STEC, including specific food items, restaurants, water sources, travel, pets, and other animal exposures were included.

Of nine laboratory-confirmed cases of STEC, eight (89%) were among children (age range: 1-7 years). All HUS cases were among children (age range: 1-6 years). Four (44%) cases occurred following attendance at the same live animal exhibit and five (56%) occurred among household contacts of children who were ill after attending the animal exhibit. Whole genome sequencing patterns for STEC O157:H7 were closely related, indicative of a common exposure. The common exposure reported among the nine patients with STEC infections was attending the animal exhibit or being a household contact of an attendee.

The animal exhibit included animal species from different farms. Cattle, sheep, goats, pigs, rabbits, a pony, and poultry were on display. Approximately 2,300 elementary school students (primarily kindergarten and second grade students) from Washington and Sullivan counties attended the event on September 26 and 27, 2023. Students were supervised by teachers and chaperones. Students were allowed to touch animals in certain areas of the exhibit. Milk was reportedly served in individual-sized cartons after students milked an artificial cow. Food (pizza) was served in a separate, enclosed building away from the animal exhibit. Temporary handwashing stations were reportedly available outside the exhibit area, and hand sanitizer was available at various locations. The extent to which handwashing was supervised for all students is unknown.

To define the source of STEC O157:H7 exposure and to inform prevention recommendations, health department officials performed an epidemiologic study, environmental sampling, and animal testing. An online survey was sent to parents of the children who attended the animal exhibit. Questions asked about illnesses after attending the exhibit, subsequent household illnesses, and activities and behaviors (e.g., handwashing, animal contact, foods eaten). Parents or guardians that participated in the survey provided information for 443 persons who had attended the event. From information provided on the survey, or directly to the health

departments, an additional 55 people were identified who experienced diarrhea or abdominal cramps after attending the exhibit but were not tested for STEC. Twenty-three household contacts with gastrointestinal illnesses after a child attended the exhibit were identified. None of these persons reported being hospitalized, although some accessed healthcare. Three environmental samples were positive for a gene associated with STEC but the outbreak strain of STEC O157:H7 was not isolated.

Health department officials implemented control measures including communication of animal contact risk and prevention strategies with schools, families, healthcare providers, and event organizers. Communications included:

- Letters to parents were sent on October 6 and 9. These included links to information on *E. coli* and safety at animal exhibits.
    - E. coli (Escherichia coli) | E. coli | CDC
    - Stay Healthy at Animal Exhibits | Healthy Pets, Healthy People | CDC
- Letters to primary care and emergency medicine clinicians were sent October 6–10 to increase awareness of the outbreak, and diagnosis and management of STEC and HUS.
    - Shiga Toxin–Producing Escherichia coli and the Hemolytic–Uremic Syndrome (N Engl J Med 2023; 389:1402-1414)
- Prevention recommendations were shared during October 24–26 at meetings with event organizers and other animal exhibitors.
    - Compendium of Measures to Prevent Disease Associated with Animals in Public Settings, 2023 from The National Association of State Public Health Veterinarians Animal Contact Compendium Committee, available at: http://www.nasphv.org/Documents/AnimalsInPublicSettings2023.pdf

Background

On October 3, 2023, the Tennessee Department of Health (TDH) Northeast Regional Office (NERO) notified the Foodborne and Enteric Disease (FED) program of two Shiga toxin-producing *Escherichia coli* (STEC) cases reported by a healthcare center. The first patient, a [redacted] The second patient, [redacted]. Both children reported attending the same "farm days" live animal exhibit prior to illness onset. The "farm days" event was held September 26–27 for pre-K, kindergarten, and 2nd grade students from Washington County, Bristol City (TN), Kingsport City, and Sullivan County school districts.

After identifying this common exposure, the FED program, NERO, and Sullivan County Regional Health Department initiated epidemiologic, environmental, and laboratory investigations to confirm the outbreak, describe the source, and prevent further disease transmission.

Methods

Epidemiology

All persons with laboratory-confirmed STEC infection, or their parents/guardians, were interviewed with a standardized case report form specific for STEC. Data were collected on potential exposures known to be associated with STEC, including specific food items, restaurants, special events, water sources, travel, pets, and other animal exposures.

Event organizers provided a list of school classes that participated in the event. Health department staff created an event-specific online survey for case finding and exposure assessment. Questions about "farm days" animal exhibit attendance, various risk and prevention activities, and illness were included. School districts sent the survey during October 9–12 to parents of children in classes that participated in the animal exhibit. The survey was open until October 27, 2023.

Cases were classified using the following outbreak case definitions which were adapted from the Council of State and Territorial Epidemiologists surveillance case definitions (CSTE 2018)[1]:

Confirmed case:

1. Primary Confirmed Case: Laboratory-confirmed STEC infection[1] in a person with diarrheal illness within 10 days of attending the animal exhibit.
2. Secondary Confirmed Case: Laboratory-confirmed STEC infection[1] in a person with illness onset after a household member attended the animal exhibit.

Probable case: Diarrhea[2] and/or abdominal cramps in a person who attended the animal exhibit within the 10 days before becoming ill, and who was not tested for STEC.

Suspect case: Gastrointestinal illness in a household contact of a child who attended the animal exhibit with illness onset after the event and who does not meet probable or confirmed outbreak case criteria.

[1] Laboratory-confirmed STEC was defined as isolation of *E. coli* O157:H7 from a clinical specimen or isolation of *E. coli* from a clinical specimen with detection of Shiga toxin or Shiga toxin genes.
[2] Diarrhea was defined as having 3 or more loose stools in a 24-hour period.

Data were collected and stored in REDCap Electronic Data Capture tools hosted at TDH. Odds ratios with 95% confidence intervals were calculated to assess the likelihood of different exposures at the exhibit being associated with reported illnesses. Analyses were conducted using SAS version 9.4 (SAS Institute, Inc.).

Environmental Health

On October 5, health department staff visited the event site and conducted an environmental assessment that included collecting environmental samples from animal areas for microbiologic testing. From October 10–13, health department staff conducted additional environmental sampling of some animals and animal areas at farms that had on exhibit. On October 26, health department staff again visited the event site to review the environmental assessment. A total of 31 environmental samples were collected by the health department during site visits. All samples were delivered to the Tennessee state public health laboratory (SPHL).

Laboratory

Clinical samples received at the SPHL were tested first by polymerase chain reaction (PCR) for stx1 and stx2 genes associated with Shiga toxin production. Isolation of *E. coli* by culture was attempted at the SPHL for all clinical specimens. Environmental samples were tested by the SPHL for stx1 and stx2 genes and culture. Environmental samples were also sent by the SPHL to the United States Department of Agriculture (USDA) Agroecosystem Management Research Unit for isolation of STEC. Isolates cultured by the USDA that were suspected to be *E. coli* O157 were sent to the SPHL for further identification. *E. coli* O157 isolates identified in clinical or environmental samples had whole genome sequencing (WGS) performed at the SPHL.

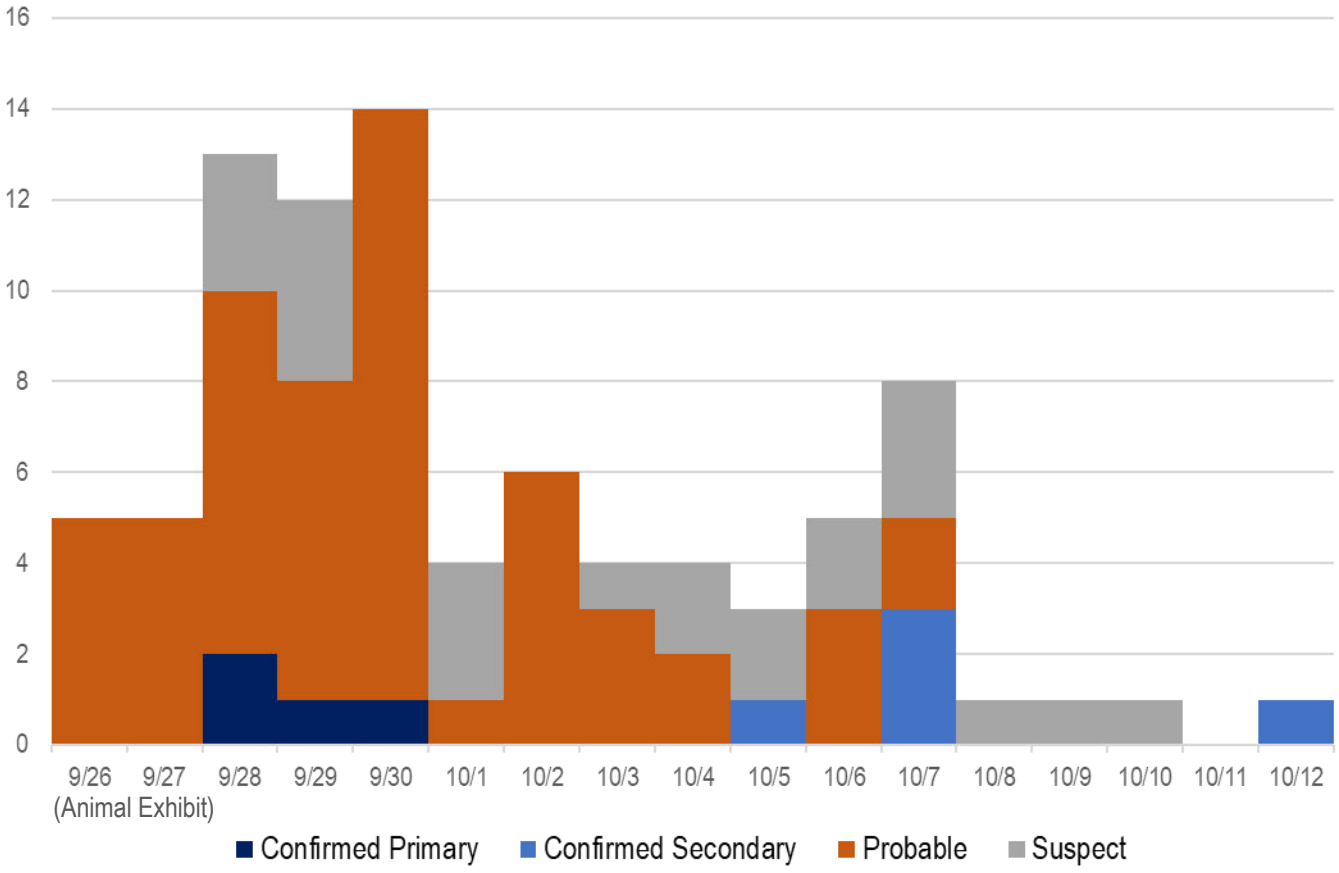
Results

Epidemiology

Nine confirmed, 55 probable, and 23 suspect cases were identified. Of nine confirmed cases, four were primary and five were secondary cases. Seven children were hospitalized and four developed HUS. There were no deaths. Among nine confirmed cases, five (56%) occurred in

males and ages ranged from 1 to 34 years. Among four HUS cases, two (50%) occurred in males and ages ranged from 1 to 6 years. Among 55 probable cases, 29 (53%) occurred in males and median age was 5 (interquartile range: 5–7) years. Illness onset dates occurred between September 26 and October 12 (Figure 1).

Figure 1. Illness onset dates, by case classification – TN23-037.



Approximately 2,300 children attended the exhibit and parents or guardians for 443 persons responded to the survey (response rate = 19%). None of the surveyed persons who reported diarrheal illness reported being hospitalized, although some were evaluated in healthcare clinics or emergency departments. Analysis of reported handwashing and animal contact among persons who attended the event and became ill and those who attended the event and didn't become ill found animal contact increased risk (OR 2.38) and handwashing decreased risk (OR 0.59). Notably, neither of these risk factors reached statistical significance in the case-control analysis (Table 1 and 2).

Table 1. Demographic characteristics of persons who attended the exhibit, by case classification – TN23-037.

	Primary Confirmed & Probable Cases (n = 59)	Control Responses (n =374)
County		
Sullivan	28 (47%)	143 (38%)
Washington	25 (42%)	188 (50%)
Other	0	4 (1%)
Missing	6 (10%)	39 (10%)
Age, median (interquartile range)	5 (5–7)	6 (5–7)
Missing	3 (5%)	6 (2%)
Age (category)		
Younger (≤6 years)	35 (59%)	202 (54%)
Older (>6 years)	21 (36%)	166 (44%)
Missing	3 (5%)	6 (2%)
Sex		
Female	24 (41%)	31 (53%)
Male	31 (53%)	187 (50%)
Missing	4 (7%)	5 (1%)
Race		
White	54 (92%)	332 (89%)
Other	1 (2%)	36 (9%)
Missing	4 (7%)	6 (2%)
Ethnicity		
Hispanic	1 (2%)	14 (4%)
Not Hispanic	53 (90%)	343 (92%)
Missing	5 (8%)	17 (5%)
Grade		
Pre-K	3 (5%)	4 (1%)
Kindergarten	28 (47%)	187 (50%)
First	1 (2%)	1 (<1%)
Second	18 (31%)	158 (42%)
Third	0	3 (1%)
Missing	9 (15%)	21 (6%)

Table 2. Exposures reported for persons who attended the exhibit, by case classification – TN23-037.

	Primary Confirmed & Probable Cases (n = 59)	Control Responses (n =374)	OR	95%CI
Date attended[1]				
First (9/26)	30 (51%)	198 (53%)	0.84	0.47-1.48
Second (9/27)	25 (42%)	138 (37%)	(ref)	
Other/Unsure	4 (7%)	19 (5%)		
Missing	0	19 (5%)		
Touched Animals				
Yes	54 (92%)	340 (91%)	2.38	0.55-10.26
No	2 (3%)	30 (8%)	(ref)	
Missing	3 (5%)	4 (1%)		
Handwashing				
Yes	44 (75%)	331 (89%)	0.59	0.27-1.30
No	9 (15%)	40 (11%)	(ref)	
Missing	6 (10%)	3 (1%)		
Foods consumed[2]				
Pizza	48 (81%)	315 (84%)	1.12	0.51-2.50
Milk	26 (44%)	188 (50%)	0.89	0.50-1.56
Cookies	25 (42%)	206 (55%)	0.73	0.41-1.30
Food from home	6 (10%)	45 (12%)	0.98	0.39-2.43

[1] Odds ratios calculated excluding responses with other/unsure or missing date.

[2] Odds ratios calculated comparing responses that reported each food was consumed to responses that did not report that food was consumed at the exhibit.

Environmental Health

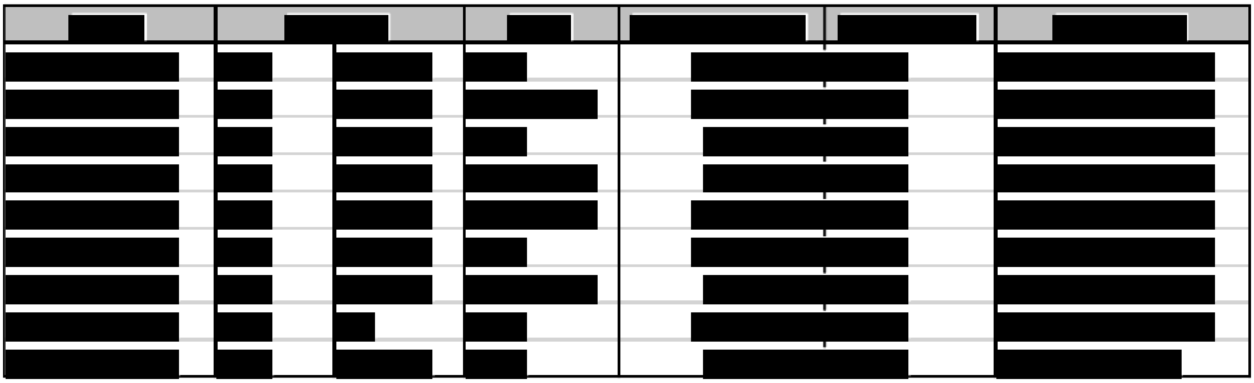
The exhibit occurred during September 26–27 and included animals from several area farms. Animals on exhibit included cattle, sheep, goats, pigs, rabbits, a pony, and poultry. Approximately 2,300 elementary school students attended (primarily kindergarten and second grade students) from Washington and Sullivan counties. Students were supervised by teachers and chaperones. After students visited various live animal stations, they could milk an artificial cow. Children were then offered pasteurized milk in a sealed individual-sized carton which they could open and drink on bleachers overlooking the animal exhibits. Fixed and temporary handwashing stations were reportedly available outside the exhibit area, and hand sanitizer was available at various locations. The extent to which handwashing was supervised for all students is unknown. Children were then served pizza and cookies in a separate, enclosed building away from the animal exhibit.

Fifteen environmental samples were collected from bedding material, feces, and surfaces in animal petting and observation areas during the environmental assessment on October 5. Sampled areas included pig, calf, cow, chicken, rabbit, goat, and sheep displays. Remaining feces from goat, sheep, and cow displays were collected. No animals were present when samples were collected. During October 10–13, health department staff collected another 16 samples from cooperating farms which had animals on display. These samples included manure and rectal samples from cow, sheep, and pig farms that had provided animals. Additionally, two shoe samples from a child who attended the event were collected.

Laboratory

The SPHL tested 18 stool samples from 16 ill persons that either attended the exhibit or were household contacts of a child who attended the exhibit. Nine specimens from eight persons had STEC O157:H7 isolated by culture and underwent WGS. For one specimen from a person with laboratory confirmed STEC by PCR, *E. coli* was not isolated by culture. Whole genome sequencing results indicated that isolates were closely related (0-1 alleles) with an average of 4 SNPs difference between isolates (range = 0–8 SNPs) (Figure 2). One child who attended the exhibit tested positive for both STEC O157:H7 and astrovirus. Six specimens from five other persons who attended the exhibit tested positive for other enteric pathogens, including other types of *E coli*. Two specimens tested negative.

Figure 2. Testing Results for *E. coli* O157:H7 Isolates from Clinical Specimens – [redacted]



Of seven environmental samples tested by the SPHL, three were positive for stx2 by PCR but *E. coli* was not isolated by culture. Of these samples, two were swabs taken of the fence enclosing the goat area and one was a swab of the chicken cage. Of 31 environmental samples sent to the USDA Agroecosystem Management Research Unit, three samples had four *E. coli* O157 isolates confirmed by the SPHL. Notably, all four *E. coli* O157:H7 isolates detected were unrelated to clinical isolates by WGS (365 allele difference) and were negative by PCR for stx1- and stx2-

encoding genes. Of these three samples, one was from feces in the sheep area of the exhibit and two were taken from sheep manure (Figure 3).

Figure 3. Testing Results for Environmental Specimens with Shiga Toxin Gene or *E. coli* O157:H7 Detected – TN23-037

SPHL #	Serotype		Toxin	Collection Date	Source
N23E320053-01A	EPEC	O157:H7	stx negative	10/12/2023	Sheep manure
N23E320053-01B	EPEC	O157:H7	stx negative	10/12/2023	Sheep manure
N23E320054-01	EPEC	O157:H7	stx negative	10/12/2023	Sheep manure
N23E312303-01	EPEC	:H7	stx negative	10/5/2023	Sheep area
N23E312296-01	Not isolated		stx2 positive	10/5/2023	Chicken cage
N23E312301-01	Not isolated		stx2 positive	10/5/2023	Goat area
N23E312302-01	Not isolated		stx2 positive	10/5/2023	Goat area

Discussion and Conclusion

TDH FED program, NERO, and Sullivan County Regional Health Departments investigated a large STEC outbreak linked to a "farm days" animal exhibit held September 26-27, 2023. Transmission of STEC O157:H7 was linked to this common event and most likely occurred due to contact with animals and the animal environment. The event had been held in previous years and was organized for kindergarten and second grade students at local schools. All laboratory confirmed STEC O157 cases occurred in persons who either attended the event or became ill after a family member who attended the event experienced a diarrheal illness, consistent with secondary transmission within households. Laboratory findings indicated a common exposure source with nearly identical WGS results for all human stool STEC O157 isolates.

During the environmental assessment, several factors were observed or described that likely increased risk for STEC O157 transmission. Notably, children had direct animal contact then participated in an artificial cow milking station after which they were given a sealed carton of milk to open and drink. Restrooms and a portable handwashing station were available at the event; however, these were not integrated into the flow of these activities. Supervised handwashing was not required after leaving animal areas. Additionally, cartons of milk can require extensive manipulation to open, potentially contributing to transmission from contaminated hands. Environmental testing and animal testing that was conducted after the event ended provided evidence of STEC, although ultimately the outbreak strain was not identified. The outbreak strain might not have been detected because sampling occurred in areas without the strain, or because animals were no longer shedding the bacteria when tested weeks later.

Five confirmed cases occurred in households due to secondary transmission from family members who attended the "farm days" event. Additionally, another 23 suspect cases were identified among household members experiencing gastrointestinal illnesses. The number of

secondary cases highlighted ongoing risk. TDH disseminated information about reducing household risk through actions such as cleaning shoes, disinfecting assistive equipment or strollers, and hand hygiene after attending an animal exhibit.

STEC has a low infectious dose and resides in the gastrointestinal tract of many ruminant farm animals such as cattle, goats, and sheep without causing illness in the animal.[2] STEC outbreaks from animal contact have been well documented in Tennessee, the United States, and globally.[3–11] Transmission risk has been shown to increase in outbreaks due to direct contact with animals and their environment coupled with inadequate handwashing measures.

In response to this outbreak, TDH and Sullivan County Regional Health Department worked with school officials to notify parents on October 6 and 9. Risk and prevention information was shared about STEC and staying healthy at animal exhibits.[12,13] TDH NERO and Sullivan County Regional Health Department notified primary care and emergency medicine clinicians during October 6–10 about the outbreak, provided information about STEC,[14] and encouraged stool testing of patients with diarrheal illness. During October 24-26, virtual and in-person meetings were held with event organizers, venue staff, and school districts to provide recommendations for staying healthy at animal exhibits. Recommendations from the *Compendium of Measures to Prevent Disease Associate with Animals in Public Settings* by the National Association of State Public Health Veterinarians were disseminated and discussed.[15]

TDH FED, NERO, and Sullivan County Regional Health Department identified a large STEC O157:H7 outbreak following a “farm days” animal exhibit for school children. Epidemiologic, environmental, and laboratory evidence support direct contact with ruminant animals carrying STEC O157:H7 and their environment as the likely cause. This outbreak included notable secondary transmission from infected event attendees to other household members. Measures to reduce risk at the event such as education prior to the event, supervised handwashing, and venue design were limited. Recommendations for future events were shared with event organizers, venue operators, and affected school districts.

Citations

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