

Risk of Shiga toxin-producing *Escherichia coli* (STEC) and county fairs in Washington State:  
A case-crossover study

Hannah Schnitzler

A thesis

submitted in partial fulfillment of the  
requirements for the degree of

Master of Public Health

University of Washington

2020

Committee:

Marilyn Roberts

Krisandra Allen

Program Authorized to Offer Degree:

Environmental and Occupational Health Sciences

©Copyright 2020

Hannah Schnitzler

University of Washington

**Abstract**

Risk of Shiga toxin-producing *Escherichia coli* (STEC) and county fairs in Washington State:

A case-crossover study

Hannah Schnitzler

Chair of the Supervisory Committee

Marilyn C. Roberts PhD

Department of Environmental and Occupational Health Sciences

No study has been undertaken in Washington State to determine if there is an association between agricultural fairs and Shiga toxin-producing *Escherichia coli* (STEC) infections, despite a fair associated outbreak in 2015 that sickened 60 people. The main objective of this study was to determine if there is an increased risk of reported STEC infections within seven days of a county fair in Washington State. A case-crossover study design utilizing conditional logistic regression was performed to estimate the odds ratio (OR) of STEC infection within 7 days of a county fair. Across all counties, our model estimated a 31% (95% CI: 2-66%) increase in the odds of a reported case of STEC during and within seven days of a county fair. By age group, a statistically significant OR was found among 10 to 19-year-olds who had an estimated 135% (95% CI: 33-315%) increase in the odds of STEC during and within seven days of a county fair. This study suggests that county fairs are a risk factor for STEC infections in Washington State and highlights the need for continued public health measures to reduce transmission risk at these events.

## **Introduction and Background**

### Clinical Disease and Public Health Importance of STEC

Shiga toxin-producing *Escherichia coli* (STEC) infection is caused by a diverse group of *E. coli* strains, most notably O157:H7. The incubation period of STEC is generally between two to six days and the illness resolves within five to seven days (CDC, 2019). It is estimated that over 240,000 cases occur annually in the U.S. and while most individuals recover from this infection, STEC causes an average of 30 deaths a year in the United States (CDC, 2019). While this disease is not as common as other enteric pathogens, such as *Salmonella* and *Campylobacter* spp., its ability to cause severe illness, especially among young children, has made it an important public health concern (Karmali, 2018). While STEC most commonly manifests as a self-limiting gastrointestinal illness characterized by abdominal cramping, diarrhea, vomiting, and the absence of a fever, it can cause hemorrhagic colitis and hemolytic uremic syndrome (HUS). HUS can lead to renal failure and death, as well as chronic kidney disease. This potentially fatal complication occurs in 5-10% of STEC cases and is most common among children less than 5 years of age, with HUS being the leading cause of acute renal failure among children (Karmali, 2018).

### Shiga toxin and STEC

The ability of STEC to cause HUS and death varies across serotypes. Multiple studies have investigated virulence genes and factors associated with increased fatality rates and increased risk of developing HUS. Shiga toxin 1 (Stx1) and Shiga toxin 2 (Stx2) are potent bacterial toxins produced by STEC that cause cellular damage due to protein inhibition (Melton-

Cesla, 2014). Other virulence genes have been investigated in the clinical course of STEC infections, such as the *eae* gene which encodes an adhesin intimin allowing adherence to enterocytes (Melton-Cesla, 2014). STEC carrying *eae* and *stx2* genes, specifically the subtype *stx2a*, have been shown to have an association with more severe clinical disease and the development of HUS (Brandal et al., 2015). HUS cases in the United States are most commonly caused by serotypes expressing *stx2* only, compared to those that express *stx1* or both in combination (Brooks et al., 2005). These virulence genes have been shown to vary among STEC serotypes isolated from cattle herds throughout the United States. In one study of dairy farms and county fairs, there was a significant difference between the types of Shiga toxin genes in cattle based on animal age. Calves were significantly more likely to shed STEC carrying *stx1* genes, while adult cows were significantly more likely to shed STEC carrying *stx2* genes. (Cho et al., 2006). Understanding the virulence profiles of STEC among dairy herds could provide further guidance on the risk of STEC and HUS from contact with specific age cohorts of cattle at public exhibits.

### STEC Serotypes

There are currently more than 400 recognized serotypes of STEC, with O157:H7 being the most well studied and most commonly associated with severe illness (Mathusa et al., 2010). These serotypes are distinguished and named based on the O and H antigens of the bacteria, which describe a surface antigen and flagellar antigen, respectively (Mathusa et al., 2010). A review of STEC isolates tested at the Washington State Department of Health Public Health Laboratories revealed that between 2007 and 2017, there were 1,373 confirmed cases of STEC O157, 293 cases attributed to STEC O26, and 691 attributed to other serotypes (Swoveland et al.,

2019). Differences in how STEC O157:H7 is identified in comparison to other STEC serotypes resulted in non-O157 STEC serotypes being historically underreported and unrecognized (Stigi et al., 2012). Unlike other serotypes, STEC O157 does not ferment sorbitol, and thus it can be identified on culture by using a sorbitol containing media (CDC, 2009). Because most non-O157 STEC serotypes are capable of fermenting sorbitol, identifying these are more challenging because less selective media must be used, followed by Shiga toxin testing of selected colonies and testing with O-specific antisera (CDC, 2009). Due to the increasingly recognized ability of non-O157 STEC to cause severe disease and large outbreaks, non-O157 *E. coli* became nationally notifiable in 2000 (Brooks et al., 2005; Germinario et al., 2016; Stigi et al., 2012). To increase the ability to identify non-O157 STEC, it was recommended that clinical laboratories culture for STEC O157:H7 and test for the presence of Shiga toxin with subsequent specimen submission to a public health laboratory for culture confirmation and serotyping (CDC, 2009). This corresponded with an increase in identification of cases, with non-O157 STEC serotypes accounting for 6% of cases in 2005 and 41% of cases in 2010 within Washington State (Stigi et al., 2012).

### Transmission

STEC is transmitted via a fecal-oral route through contact with an infected animal or human, contact with the contaminated environment of an infected animal, or consumption of contaminated food or water sources. Transmission of STEC via a foodborne route is the most common route of exposure identified among cases. The majority of *E. coli* O157 illnesses in the United States are caused by consumption of contaminated vegetable row crops (such as lettuce) or beef, which account for nearly 75% of illnesses (Pires et al., 2019). The prevalence of STEC

isolated from beef products varies across studies, with reports in King County, WA ranging from 3.7 to 23% (Samadpour et al., 1994; Samadpour et al., 2002). Contamination of crops can occur at any point along the food chain. Multiple mechanisms of contamination can occur pre-harvest, including application of animal manure, runoff from nearby farms, application of a contaminated water supply, direct contamination by animals, or deposition by birds or insects (Erickson et al., 2019). Once *E. coli* is present in the soil it can persist for months and can adhere to plants and colonize the roots, though studies have shown that internalization of *E. coli* in root systems doesn't persist for greater than seven days following exposure (Erickson et al., 2010, Rossez et al., 2014). The internalization of *E. coli* into the root system of leafy greens is influenced by a variety of factors, including the type of plant, temperature, humidity, and the concentration of the pathogen within the soil (Erickson et al., 2014).

### STEC In Agricultural Animals

While ruminants, such as cattle, sheep and goats, are considered the main reservoir for STEC, the bacteria have been isolated from the feces of multiple animal species. These include pigs, camelids, rabbits, dogs, cats, as well as wild mammals including raccoons, opossums, rats, feral swine, and wild ruminants such as deer. In addition, STEC has been found in the feces of both domesticated and wild birds (Spickler, 2016). Among cattle, the prevalence reported from herds has varied by study, with up to 19.7% of feedlot cattle and 27.4% of pasture raised cattle testing positive for STEC O157:H7 (Hussein, 2007). Additionally, up to 55.9% of feedlot cattle and 44.8% of pasture raised cattle were found to test positive for non-O157 STEC (Hussein, 2007).

The prevalence of STEC O157:H7 among cattle generally follows a seasonal pattern, with increased prevalence during warmer months of the year (Hancock et al., 1994). A study that tested feedlot cattle in the winter and summer found that STEC O103 and O157 significantly increased in the summer compared to the winter season, with other serotypes not common enough to determine seasonality (Dewsbury et al., 2015). The exact mechanisms leading to increased prevalence of STEC among cattle in the summer have not been determined, but increased exposure and transmission through changes in animal behavior and management have been hypothesized (Dawson et al., 2018). A challenge study comparing infection rates and shedding based on season found increased susceptibility in the winter when cattle were experimentally exposed to STEC, lending support to the hypothesis that extrinsic factors lead to this seasonal pattern instead of intrinsic host factors (Sheng et al., 2015). A further study evaluating behavioral factors found that higher temperatures led to cattle congregating in shady spots on pasture, increasing contact and transmission of STEC, but that increased use of water sources was not found to be associated with increased STEC in the summer (Dawson et al., 2018).

There has also been attention focused on the ability of pigs to transmit STEC to humans after wild swine were proposed to be the cause of an outbreak associated with spinach consumption (Jay et al., 2007). Multiple serotypes have been found among pig populations and have been isolated from both healthy and ill animals. A study that sampled pigs at a slaughter facility found 1.9% were positive for STEC O157:H7 (Feder et al., 2002). Another study isolated multiple serotypes from finishing pigs, including O26:H11 and O157:H7 (Wonhee et al., 2018). Additionally, there are certain serotypes that have been associated with clinical illness in pigs, causing edema disease in post-weaning and young finishing pigs, including STEC O138,

O139, O141, and O147 (Tseng et al., 2014). The identification of STEC serotypes among agricultural animals and outbreaks associated with fairs have also led to studies focused on the collection of fecal samples from animals at fairgrounds, these are highlighted below.

### STEC Transmission at Fairs

Multiple outbreaks of STEC infections have been described from agricultural fairs throughout the United States. Transmission of STEC can occur via multiple routes of exposure at an agricultural fair, including indirect or direct contact with infected animals, contamination of food, or contamination of water sources. All of these routes have been previously identified and described in outbreak investigations in association with agricultural fairs (Crump et al., 2003; Steinmuller et al., 2006). In addition, the number of outbreaks of enteric diseases associated with animals in public settings has increased, with the number reported annually prior to 2000 ranging from zero to four in comparison to four to ten outbreaks reported annually from 2000 to 2005. In this same review of outbreaks, STEC O157 was the most common pathogen implicated, accounting for 32 or 58% of the outbreaks identified in association with the public display of animals (Angulo et al., 2006).

Ruminants, such as cattle, goats, and sheep, are a well-known reservoir for STEC, and do not show clinical signs of illness despite shedding the bacteria in their feces (Hussein, 2007). Thus, exclusion of ill animals on fairgrounds does not translate to the prevention of STEC among the animals shown. While direct contact with the coat, saliva, or skin of infected animals via touching or feeding can transmit STEC, the organism is also shed into the surrounding environment. Thus, contact with the soil, gates, or other surfaces in the vicinity can pose a risk of transmission as well (Keen et al., 2006). Within fair settings, studies have isolated outbreak

strains of STEC from environmental samples such as sawdust, rafters, and handrails up to 10 months after livestock were housed in the facility (Varma et al., 2003), indicating the possibility of persistent risk following the housing of these animals. In addition, the colonization of ruminants with STEC is highest during the warm summer and fall months, coinciding with the timing of most agricultural fairs (Hancock et al., 1994).

There have been multiple studies performed to estimate and describe prevalence of STEC among animals at fairs in the United States. Two studies reported finding no STEC among cattle at county fairs sampled, though one of these studies only attempted to isolate O157:H7 (McNamara et al., 2011; Roug et al., 2013). In comparison, a study that collected samples from 12 county fairs in Minnesota found STEC at nine of the 12 (75%) county fairs (Cho et al., 2006). A study that sampled multiple species at 32 county and state fairs found that 11.4% of cattle, 5.2% of fly pools, and 3.6% of sheep and goats were positive for STEC O157:H7 (Keen et al., 2006). While the majority of studies have focused on cattle and other ruminants, a few studies have also sampled additional species shown at fairs for STEC. Two studies reported fecal samples from pigs at fairgrounds testing positive for *E. coli* O157:H7. In one of these studies, the only animal to test positive among animals sampled at fairs for O157:H7 was a pig (Roug et al., 2013). In another study that sampled animals at fairgrounds in the United States, 1.2% of swine tested positive for STEC O157:H7 (Keen et al., 2006). The majority of these studies have focused on isolating STEC O157:H7 without further testing or identification of other serotypes, leading to a knowledge gap of the prevalence of these serotypes in fair settings.

Waterborne routes of exposure in fair related outbreaks have been identified and reported to be due to aging infrastructure and lack of maintenance at agricultural fair grounds. (Crump et al., 2003; Steinmuller et al., 2006). In general, STEC outbreaks associated with drinking water

typically affect smaller water systems or wells, though large outbreaks of up to 1,400 cases have occurred due to a contaminated water source (Olsen et al., 2002). Waterborne routes of infection have been identified in at least two fair associated outbreaks of STEC in which livestock manure contaminated the water supply. The largest of these outbreaks occurred at the New York State Fair in 1999 where more than 1,000 people became ill and at least 2 fair attendees died. The use of fairground water sourced from a well contaminated by livestock manure to make ice and drinks was identified as the cause of this outbreak in New York (Charatan, 1999). Similarly, an outbreak at a county fair in Ohio in 2000 affecting 22 people was linked to the consumption of products made with water from the fairgrounds after the water system was identified as being contaminated with manure runoff (Crump et al., 2003).

While the previous studies described have estimated the prevalence of STEC O157:H7 among animals shown at agricultural fair exhibits and described outbreaks associated with attending these events, only one study has been conducted to estimate the risk associated with fairs. This study was performed in Ohio following an STEC outbreak affecting 22 fairgoers. Household survey results estimated that residents who attended a county fair were 8.2 times more likely to develop an *E. coli* O157 infection and an ecological study reviewing surveillance records of STEC found a significant increase in STEC following the occurrence of a county fair in Ohio (Crump et al., 2003). Within Washington State, a large outbreak occurred in 2015 in association with the Milk Makers Festival in Whatcom County. This outbreak led to at least 60 cases of STEC, with six individuals developing hemolytic uremic syndrome (CDC, 2015). Despite the known risk factors present at agricultural fairs, the susceptible population in attendance at these events, and reported outbreaks of STEC at agricultural fairs in the state, there has never been a study to determine if there is an increased risk of STEC associated with

agricultural fair occurrence in Washington. In addition, no study incorporating non-O157 serotypes in the determination of STEC risk in association with fairs has been performed to date. To investigate this gap in knowledge, we performed a case-crossover study and descriptive analysis to determine if there is an association between county fair occurrence and reported STEC incidence in Washington State.

## **Methods**

### STEC Case Data

STEC incidence was determined by acquiring surveillance system records from the Washington State Department of Health (WA DOH). STEC infection is a notifiable condition in Washington State and all cases that test positive for Shiga toxin or STEC are required to be reported to public health. A clinical sample that tests positive for *E. coli* O157:H7 or Shiga-toxin is required to be submitted to the WA DOH Public Health Laboratories within two days for confirmatory testing and is immediately notifiable to the local health jurisdiction. The local health jurisdiction conducts a case investigation using a standardized reporting form. This form includes questions regarding symptom onset and clinical symptoms, as well as possible food, water, and animal exposures during the incubation period (reporting form included in Appendix 1 for reference). Included in the animal exposure section are questions regarding fair attendance and animal contact. Animal contact, petting zoo exposure, dairy farm exposure, county/state fair exposure and the corresponding notes sections were obtained from the reporting forms to determine if agricultural fair attendance was reported by cases. To assess for an overall spatiotemporal association between reported STEC incidence and agricultural fair occurrence, county of likely exposure, and county of residence were acquired for all reported cases of STEC.

In addition, demographic and clinical information including age, sex, hospitalization, death, and development of HUS were obtained for each reported case.

All reported cases of STEC between 2010 and 2017, including confirmed, probable, and suspected cases, were requested. The case definition for STEC was updated by the Council of State and Territorial Epidemiologists (CSTE) in 2014. The case definition for confirmed and suspect cases remained the same after this update, with the case definition for a probable case changed to include members of a defined risk group during an STEC outbreak, this is marked with an asterisk below. It should be noted that, while not changed during the time period of the study, the case definition for STEC was changed in 2018 to include clinically compatible cases with identification of Shiga toxin production or genes, but no *E. coli* culture confirmation, as probable and not suspect cases. The case classifications utilized during the time period of this study as defined by CSTE (2015) are as follows:

- Confirmed:** Isolation of *E. coli* O157:H7 or isolation of *E. coli* from a clinical specimen with confirmation of Shiga toxin or the presence of Shiga toxin genes
- Probable:** A case with isolation of *E. coli* O157 from a clinical specimen without confirmation of the H antigen or Shiga toxin production
- OR** A clinically compatible case who is a contact of an STEC case or is member of a defined risk group during an outbreak\*
- OR** Identification of an elevated antibody titer to a known STEC serotype from a clinically compatible case
- Suspect:** A case of post-diarrheal hemolytic uremic syndrome (HUS)
- OR** Identification of Shiga toxin in a specimen from a clinically compatible case without the isolation of *E. coli*

STEC cases without a recorded date of symptom onset, STEC cases for which the region of exposure was classified as a country or state other than Washington, and STEC cases without a county of residence listed were excluded from the analysis. The Washington State Institutional Review Board determined this study to be exempt from full review.

### Fair Data

To determine a probable fair exposure, defined as the occurrence of a county fair within a case patient's county of residence, data was collected on county fairs that occurred in Washington State from 2010 through 2017. The Washington State Fair (Puyallup Fair), which attracts people from throughout the state of Washington, as well as out of state visitors, was excluded from this analysis. County fair data, including dates of occurrence and overall attendance numbers, was acquired from the Washington State Department of Agriculture's Fairs Program. Information was available for 37 county fairs from 2010-2017. Jefferson County was the only county not included in the data from the WSDA Fairs Program and thus the eight STEC cases reported from this county were excluded from the study. Benton and Franklin counties have a combined fair which was included as an exposure variable for both counties in the case-crossover analysis.

### Analysis

We utilized a case-crossover study design to examine the association between county fair occurrence and STEC by county of residence. The case-crossover study design defines a hazard and referent period for each individual in the study, thereby each individual case serves as their

own control. This study design was initially utilized to prevent sampling bias due to control selection in the study of possible triggers for myocardial infarctions but has since been used to estimate risk factors for infectious disease utilizing the incubation period as the hazard period (Dixon, 1997; Maclure and Mittleman, 2000). The exposure for this analysis was defined as the occurrence of a county fair within the county of residence. The study design compares the occurrence of this exposure during the hazard period to the occurrence of this exposure during a referent period (or control period) for the same case. The hazard period was defined as the incubation period of STEC, specified as one to seven days prior to the symptom onset date for each case. The referent period for each case was defined as a period of six days, 22-28 days prior to the date of symptom onset. This study design relies on individuals with discordant exposure, defined as those with exposure to a county fair occurring in either the hazard or referent period, to calculate the odds ratio associated with the exposure. The case-crossover design controls for time-invariant characteristic such as age, sex, underlying medical conditions, and other individual level risk factors as the case serves as their own control. The referent period was selected to avoid overlap with the incubation period which has been reported to occasionally occur up to 10 days, while still maintaining similar seasonality to control for time variance in fair occurrence. Regression analysis was completed utilizing the clogit function in the survival package in R (R 3.4.3) to perform conditional logistic regression.

## **Results**

### Study Sample

A total of 2,462 cases of STEC were reported to the Washington State Department of Health between 2010 and 2017 and collected for our study. There were 71 cases removed from

the study due to a state or country other than Washington being listed as the exposure location. Records that were marked as duplicates were then removed from the dataset, this included 4 cases. Only one case did not have a symptom onset date reported and was removed from our dataset. In addition, due to the necessity of county of residence information to determine the timing of fair occurrence for each case, a total of 16 cases were removed due to lack of county of residence information. Finally, eight cases from Jefferson County were removed due to lack of data on fair occurrence in this county, bringing the total included in the study to 2,367 reported cases of STEC.

#### Characteristics of all reported STEC cases, 2010-2017

A total of 2,367 STEC cases that were reported from 2010 through 2017 in Washington state were included in the analysis, the characteristics of these cases are reported in Table 1. Of these reported cases, a total of 1,951 (82.4%) were classified as confirmed, 160 (6.8%) were classified as probable STEC cases, and 256 (10.8%) were classified as suspect cases of STEC. Overall, of the 2,637 reported STEC cases, 24.1% were hospitalized, 5.4% developed hemolytic uremic syndrome, and 0.3% died from the infection during this reporting period.

#### Characteristics of reported STEC cases included in the case-crossover study

The number of cases with discordant exposure, and thus included in the conditional regression analysis, was 270. The descriptive characteristics of these 270 cases are reported in Table 1. Of these 270 cases, 153 (56.7%) had a fair occur in their county of residence during the incubation period for STEC and the other 117 (43.3%) had a fair occur in their county of residence during the referent period. The proportion of cases identifying as female was higher

among cases occurring during or within seven days of a county fair compared with cases who had a fair occur during the referent period. In addition, the age group between 10 and 19 years old was more highly represented among cases that occurred during or within seven days of a fair compared to cases occurring 3 weeks after a fair (26.1% vs 14.5%) (Table 1). Clinical outcomes including hospitalization, hemolytic uremic syndrome and death were relatively similar between the two groups.

### Case-crossover results

The results of the statewide and county-level analyses are presented in Table 2. Our model estimates a 1.31 (95% CI: 1.02-1.66) times greater odds of a reported STEC case within seven days of a county fair compared to cases without a county fair occurring in their county of residence during the incubation period (Table 2). The increase in reported STEC cases following the occurrence of a county fair is shown in Figure 1. We conducted sub-analyses stratified by age group and county of residence. The association between a county fair and STEC was not statistically significant for any single county examined. An additional model was used to incorporate the 2015 Milk Makers Festival as an exposure variable. This fair in Whatcom County was associated with a large STEC outbreak, eventually sickening 60 people. With this fair included in the analysis, the overall statewide odds ratio was estimated to be 1.59 (95% CI: 1.26-2.00) and was statistically significant at the county level for Whatcom county with an estimated odds ratio of 4.23 (95% CI: 2.31-7.74) (Table 2).

The number of STEC cases that occurred within seven days of a county fair were mapped by county and year to visualize the spatial variation in these cases. King County had cases reported within seven days of a county fair in all years of the study (Figure 2). Other counties

that most frequently reported cases within one week of a county fair included Whatcom County, Kittitas County, Snohomish County, and Clark County (Figure 2). Counties with the largest number of cases within a given year were King, Clark, Snohomish, and Whatcom counties, which all had at least six cases reported in a single year (Figure 2). This correlates well with the number of STEC case patients reporting attending a fair during their exposure period, with the majority from Whatcom County (29 cases, 42%). Other counties associated with the most STEC cases reporting fair exposure were King (8 cases, 11.6%), Snohomish (5 cases, 7.2%), Clark (4 cases, 5.8%) and Spokane (4 cases, 5.8%). Even after removing the MMF cases from the dataset, Whatcom County accounted for the majority of case patients reporting fair exposure (17.4%).

The results of the age group analysis are presented in Table 3. The only age group with a statistically significant odds ratio was among those 10 to 19 years of age. The model estimated a 135% (95% CI: 33-315%) increase in the odds of an STEC infection during and within seven days of a county fair compared to three weeks after a county fair in this age group (Table 3).

#### Serotype and Shiga toxin type of STEC cases occurring within seven days of a county fair

Of the 153 cases that occurred within seven days of a county fair, 123 (80.4%) had culture results available. A total of thirteen different serotypes based on the O antigen were reported and are summarized in Table 4. The most common serotype reported was O157, which accounted for 63.4% of cases, while O26 was the second most common serotype, accounting for 15.4% of cases. The occurrence of STEC serotypes was not consistent across years within a county. There was also within year variation of STEC serotypes among cases occurring during

and within seven days following a fair, with 37% of counties reporting two or more serotypes in a given year (Table 4).

Shiga toxin type was available for 116 out of the 153 cases (75.8%) that occurred within seven days of a county fair. Shiga toxin 2 (Stx2) was the most common, accounting for 44 (37.9%) of these cases, Shiga toxin 1 (Stx 1) accounted for 35 (30.2%) cases and both Stx1 and Stx2 were reported in 37 (31.9%) cases. The percentage of cases with the presence of Stx1 confirmed ranged from 8.3 to 100%, Stx2 ranged from 7.7 to 56.2%, and the percentage of cases with both Stx1 and Stx2 confirmed ranged from 6.2 to 58.3% (Figure 3).

## **Discussion**

This study is the first to estimate the association between county fair occurrence and STEC infections in Washington State. In addition, this study is the only study to incorporate non-O157 STEC serotypes into the estimation of STEC risk associated with fair occurrence. Our study estimates a 1.3 (95% CI: 1.03-1.66) times greater odds of a reported STEC case within seven days of a county fair compared to a period three weeks after a county fair. No other case-crossover study has been performed to estimate the odds ratio of STEC and county fair occurrence, however, a previous study in response to an outbreak of *E. coli* O157:H7 at a fair in Ohio combined a case-control study of the outbreak with an ecological study to estimate risk of fairs and *E. coli* O157:H7. Our results are in accordance with this previous study, which found a significant increase in *E. coli* O157:H7 cases during and within seven days of a fair by county, with an estimated hazard rate of 1.7 (95% CI: 1.0-2.8) (Crump et al., 2003). When reported STEC cases are visualized by date of symptom onset in relation to the start date of a county fair, a peak within approximately ten days of the fair start date can be seen (Figure 1). In addition, this

overall peak follows that of STEC cases who reported attending a fair during their incubation period as reported in their case investigation form (Figure 1). These results suggest that county fairs are a risk factor for STEC in Washington State.

Our study further subdivided the analysis by county and age group. No county had a statistically significant odds ratio in our primary model, likely due to relatively low sample numbers when stratified by county (Table 2). However, the addition of the Milk Makers Festival in 2015 as an exposure variable in the model resulted in an increased estimate for the statewide odds ratio (OR:1.59, 95% CI: 1.26, 2.00) and a statistically significant odds ratio for Whatcom County. Inclusion of these cases resulted in an estimated odds ratio of 4.23 (95% CI: 2.31-7.74) for Whatcom County, which is much higher than the estimated statewide odds ratio, as well as individual counties (Table 2). The addition of the Milk Makers Festival as an exposure variable in 2015 added 33 cases to the model, all exposed during the hazard and not referent period, thus increasing the odds ratio. Despite a total of 60 confirmed and probable cases reported in the Milk Makers Festival outbreak, only 33 were identified in this study within seven days of the fair. This is likely due to incomplete surveillance system data and because multiple cases occurred greater than seven days after the fair from secondary spread within families.

Despite no statistically significant result for individual counties in our model, visualization of the number of cases reported within a week of a county fair by year identified regions that more often reported cases during this time period. King County was the most commonly represented throughout the years, with cases reported within one week of a county fair for each year of the study period. King, Clark, Snohomish, and Whatcom counties were associated with the most cases reported in a year (Figure 2). These number correlate well with the number of STEC case patients that reported attending a fair during their exposure period.

Whatcom County accounted for the most cases, and even after removal of cases associated with the MMF, still accounted for 17.4% of STEC cases reporting fair exposure. In addition, in 2015, three STEC cases were reported within a week of the Whatcom County Fair that occurred on the same fairgrounds and four months after the MMF outbreak that year, possibly indicating persistent contamination. Other counties associated with the most STEC cases reporting fair exposure were King (11.6%), Snohomish (7.2%), Clark (5.8%) and Spokane (5.8%) counties. The identification of these counties as having the most cases following a county fair may be useful in targeting public health messaging and preventative efforts. However, the higher number of cases reporting fair exposure could be associated with the higher population levels in these counties.

While our *a priori* hypothesis was that young children would have the highest risk of STEC infection, the age group with the highest odds ratio, and the only statistically significant result was among 10 to 19-year-olds, with an estimated OR of 2.35 (95% CI: 1.33-4.15). The median age of STEC cases that occurred within seven days of a county fair was 14 in this study. The likelihood of exposure at fairs may differ by age group based on the specific routes of exposure present, with fair outbreak investigations reporting median age ranges from four to 26. The recognized sources of STEC exposure in fair settings vary and range from contaminated seating areas to direct animal contact. An outbreak investigation of 108 STEC cases associated with the North Carolina State Fair in 2004 found frequent hand-to-mouth contact and falling or sitting on the ground to be risk factors for infection at the fair. Many of the individuals infected reported visiting a petting zoo at the fair and this was determined to be the likely route of exposure. The median age for this outbreak was 5.4 years old (Goode et al., 2009). A younger median age appears to be more common among outbreaks involving petting zoo settings at fairs,

with three outbreaks from Florida petting zoos in 2005 having a median age of 4 years old (CDC, 2005). However, other fair-related outbreak studies reported higher median age when the route of exposure was not identified to be a petting zoo. An outbreak of STEC at the North Carolina State Fair in 2011 reported a median age of 26 years old and the only exposure associated with increased risk of illness was visiting an animal exhibit barn with no direct animal contact reported by cases (CDC, 2012). An outbreak of 25 cases at a county fair in Texas reported a median age of 17 years old, and found that showing a pig or accompanying an exhibitor showing a pig, visits to the livestock barn, and the number of days of attendance were associated with increased risk of infection (Durso et al., 2005). The wide array in exposure settings that can occur in fair settings is likely the source of these age-related differences in outbreaks, and the relatively older median age of cases reported in this study may indicate routes of exposure more prevalent among individuals of this age group, such as showing animals or volunteering in barns, or the combination of different exposure routes from outbreaks over the study period.

The majority of studies describing STEC outbreaks associated with agricultural fairs have focused solely on *E. coli* O157:H7, this study is unique in that it incorporated all reported STEC serotypes and sought to describe the frequency and distribution of these serotypes among cases occurring during or within seven days of a fair. It was hypothesized that STEC O157:H7 would be the most frequent serotype isolated, as it is the most common serotype reported among Washington residents and the most prevalent serotype in cattle herds (Mellor et al., 2016; Swoveland et al., 2019). While *E. coli* O157 was the most frequently reported serotype among cases occurring within seven days of a county fair, accounting for 63.4% of cases, serotypes O26 and O121 accounted for 15.4% and 5.7% of cases respectively. These two serotypes are

commonly reported as the two most common serotypes below *E. coli* O157 in both humans and cattle, thus it is not surprising that they were relatively common among cases in our study (Bettelheim, 2007; Bonardi et al., 2015; Mellor et al., 2016). Overall, non-O157 STEC serotypes accounted for 45 (36.6%) cases that occurred within a week of a county fair (Table 4). These results highlight the need for identifying and including non-O157 STEC serotypes in outbreak investigations, environmental studies, and risk factor analyses in future studies.

Our study found that that the majority of cases within a county occurring within seven days of a county fair belonged to one serotype in a given year (Table 4). However, 37% of counties reported two or more STEC serotypes among cases occurring within seven days of a county fair in at least one year of the study period (Table 4). The presence of multiple serotypes at a fairground can occur due to animals being sourced from a wide geographic range within the county and multiple species being housed in these facilities. Contact with farm animals has been found to be more common among STEC case patients who have multiple serotypes of STEC isolated from their stool (Luna-Gierke et al., 2014). However, the majority of studies describing STEC prevalence among animals at fairs have only sought to describe STEC O157, and thus information on the prevalence of other serotypes and the diversity of serotypes among these animals is lacking. It is also common to identify multiple PFGE patterns of a single serotype among cattle and environmental samples from fairgrounds (Cho et al., 2006). While in many fair outbreak investigations there is a main outbreak strain identified using pulsed-field gel electrophoresis (PFGE) or whole genome sequencing (WGS), other strains are commonly found among cases and matched to environmental samples taken from fairgrounds. For instance, an outbreak investigation at the North Carolina State Fair identified multiple PFGE patterns among cases, with different areas of the county fair yielding matching samples and prompting the

investigators and authors of the study to determine that there were multiple sources of illness at the fair (Goode et al., 2009). Other outbreak investigations and studies have found multiple PFGE patterns of STEC O157 present among cattle and in the environment, with one outbreak investigation reporting seven different distinguishable strains isolated from environmental samples (Durso et al., 2005; Keen et al., 2006).

The presence of multiple serotypes and PFGE patterns among STEC isolates from exhibit animals, environmental samples, and even case patients in an outbreak can complicate public health investigations of these cases. This study reports the isolation of 13 different serotypes from cases that occurred within a week of a county fair, highlighting the need for further studies to determine the distribution and risk of non-O157 serotypes at fairgrounds to provide stronger evidence for the investigation of STEC clusters involving more than one serotype from a fair.

### **Limitations**

A main limitation of this study is that it is an ecological study, and thus individual risk of STEC in association with fair attendance cannot be determined. This study characterized a probable fair exposure in the analysis, and thus it is likely that some cases identified within seven days of a county fair did not attend the fair and were not associated with its occurrence. It is also possible that fair associated cases were not captured in this definition due to an incubation period longer than seven days, or through secondary spread as was reported in the Milk Makers Festival outbreak (CDC, 2015). Because of this, the results should only be interpreted as an increase in the odds of a reported STEC case at the county level within seven days of a fair, and not as the individual level risk of attending a county fair. In addition, the confidence interval for this study is relatively wide, with the lower estimate only a 3% increase in the odds of a reported case of

STEC in a county (Table 2). This is likely due to relatively low sample sizes in the case-crossover analysis. There were only 153 cases of STEC occurring within seven days of a county fair in Washington from 2010 through 2017 and a total of 270 cases with discrepant results for the case-crossover analysis, limiting the power of this study.

The use of surveillance records and reported cases means that the true burden of STEC infections was not captured, as many cases of enteric infections may go undiagnosed due to individuals not seeking medical attention, physicians not ordering diagnostic tests, or samples not being properly submitted. For STEC O157:H7, it is estimated that there are an additional 26 cases for each case diagnosed, while for non-O157 STEC it is estimated that there are approximately 107 cases for every case that gets diagnosed (CDC, 2011). However, these estimates of underdiagnosis were made in 2011 and may not completely represent improvements made to the diagnosis and reported of non-O157 STEC more recently (Stigi et al., 2012).

Further studies should be performed to determine the true number of fair attendees who develop symptoms of STEC to establish incidence and risk among fairgoers in Washington State. However, identifying an increase in reported STEC during and after a fair within a county may inform public health officials regarding risk to support outbreak investigations and public health education at these events.

## **Conclusions**

This study is the first to estimate the risk of reported STEC infections with county fair occurrence in Washington State, and the only study to include multiple serotypes of STEC in the analysis of this association. Our finding of an increased risk of STEC within a county following a fair may inform public health professionals in risk identification and mitigation, such as

ensuring the implementation and adherence to recommendations made by the National Association of State Public Health Veterinarians (NASPH) regarding the public display of animals. While these findings suggest that county fairs are a risk factor for STEC infection in Washington State, additional research is needed to determine individual risk of attending a fair and to include smaller agricultural fairs that occur annually in addition to county fairs.

## Tables

**Table 1.** Descriptive characteristics of all reported STEC cases in Washington, 2010-2017, and of the reported STEC cases included in the case-crossover analysis

	N (%)	N (%) with discordant exposure <sup>a</sup>	N (%) exposed during hazard period <sup>b</sup>	N (%) exposed during referent period <sup>c</sup>
<b>Total</b>	2,367 (100)	270 (100)	153 (100)	117 (100)
<b>Case Classification</b>				
Confirmed	1,951 (82.4)	225 (83.3)	124 (81.0)	101 (86.3)
Probable	160 (6.8)	27 (10)	16 (10.5)	11 (9.4)
Suspect	256 (10.8)	18 (6.7)	13 (8.5)	5 (4.3)
<b>Sex</b>				
Female	1,329 (56.1)	157 (58.1)	97 (63.4)	60 (51.3)
Male	1,032 (43.6)	113 (41.9)	56 (36.6)	57 (48.7)
Not reported	6 (0.3)	0 (0)	0 (0)	0 (0)
<b>Age group</b>				
0-4	610 (25.8)	69 (25.6)	33 (21.6)	36 (30.8)
5-9	266 (11.2)	37 (13.7)	22 (14.4)	15 (12.8)
10-19	400 (16.9)	57 (21.1)	40 (26.1)	17 (14.5)
20-39	551 (23.3)	33 (12.2)	30 (19.6)	27 (23.1)
40-59	275 (11.6)	27 (10.0)	15 (9.8)	12 (10.3)
60+	265 (11.2)	23 (8.5)	13 (8.5)	10 (8.5)
<b>Hospitalized</b>				
Yes	571 (24.1)	73 (27.0)	40 (26.1)	33 (28.2)
No	1,783 (75.3)	196 (72.6)	112 (73.2)	84 (71.8)
Unknown	13 (0.6)	1 (0.4)	1 (0.7)	0 (0)
<b>Died</b>				
Yes	8 (0.3)	1 (0.4)	0 (0)	1 (0.9)
No	2,322 (98.1)	264 (97.8)	148 (96.7)	116 (99.1)
Unknown	37 (1.6)	5 (1.8)	5 (3.3)	0 (0)
<b>HUS</b>				
Yes	129 (5.4)	18 (6.7)	9 (5.9)	9 (7.7)
No	2,035 (86.0)	227 (84.1)	130 (85.0)	97 (82.9)
Unknown	203 (8.6)	25 (9.3)	14 (9.1)	11 (9.4)

<sup>a</sup>Reported STEC cases with a county fair occurring in their county of residence in either the hazard or referent period (not including the 2015 Milk Makers Festival as an exposure variable).

<sup>b</sup>Reported STEC cases with a county fair occurring in their county of residence during the hazard period (1-7 days prior to symptom onset) and not the referent period (not including the 2015 Milk Makers Festival as an exposure variable).

<sup>c</sup>Reported STEC cases with a county fair occurring in their county of residence during the referent period (22-28 days prior to symptom onset) and not the hazard period (Not including the 2015 Milk Makers Festival as an exposure variable).

**Table 2.** Odds ratios (ORs) and 95% confidence intervals of STEC infection by county

County	N (%)	OR (95% CI)	# of STEC cases (%) with discordant exposure <sup>a</sup>	# of STEC cases (%) exposed during hazard period <sup>b</sup>
All counties	2,367 (100)	1.31 (1.03, 1.66)*	270 (100)	153 (100)
All counties+MMF <sup>c</sup>	2,367 (100)	1.59 (1.26, 2.00)*	303	186
Adams	3 (0.1)		1 (0.4)	1 (0.7)
Asotin	7 (0.3)		0 (0)	0 (0)
Benton	55 (2.3)		7 (2.6)	0 (0)
Chelan	19 (0.8)		4 (1.5)	4 (2.6)
Clallam	13 (0.5)		0 (0)	0 (0)
Clark	240 (10.1)	1.42 (0.79, 2.56)	46 (17)	27 (17.6)
Cowlitz	27 (1.1)		1 (0.4)	1 (0.7)
Douglas	6 (0.3)		1 (0.4)	1 (0.7)
Ferry	1 (0)		0 (0)	0 (0)
Franklin	27 (1.1)		1 (0.4)	0 (0)
Garfield	4 (0.2)		0 (0)	0 (0)
Grant	44 (1.9)	0.33 (0.07, 1.65)	8 (3.0)	2 (1.3)
Grays Harbor	15 (0.6)		1 (0.4)	0 (0)
Island	17 (0.7)		2 (0.7)	2 (1.3)
Jefferson	0 (0)		0 (0)	0 (0)
King	682 (28.8)	1.15 (0.68, 1.92)	58 (21.5)	31 (20.3)
Kitsap	31 (1.3)		1 (0.4)	1 (0.7)
Kittitas	72 (3.0)	2.67 (0.71, 10.0)	11 (4.1)	8 (5.2)
Klickitat	9 (0.4)		0 (0)	0 (0)
Lewis	36 (1.5)	0.75 (0.17, 3.36)	7 (2.6)	3 (2.0)
Lincoln	4 (0.2)		0 (0)	0 (0)
Mason	10 (0.4)		0 (0)	0 (0)
Okanogan	12 (0.5)		1 (0.4)	1 (0.7)
Pacific	3 (0.1)		2 (0.7)	0 (0)
Pend Oreille	3 (0.1)		0 (0)	0 (0)
Pierce	168 (7.1)	1.50 (0.42, 5.32)	10 (3.7)	6 (3.9)
San Juan	6 (0.3)		0 (0)	0 (0)
Skagit	58 (2.5)	0.33(0.03, 3.20)	4 (1.5)	1 (0.7)
Skamania	3 (0.1)		0 (0)	0 (0)
Snohomish	222 (9.4)	1.50 (0.76, 2.95)	35 (13.0)	21 (13.7)
Spokane	123 (5.2)	2.25 (0.69, 7.31)	13 (4.8)	9 (5.9)
Stevens	13 (0.5)		1 (0.4)	1 (0.7)
Thurston	98 (4.1)	0.67 (0.19, 2.36)	10 (3.7)	4 (2.6)
Wahkiakum	1 (0)		0 (0)	0 (0)
Walla Walla	9 (0.4)		1 (0.4)	1 (0.7)
Whatcom	176 (7.4)	1.57 (0.80, 3.07)	35 (13.0)	22 (14.4)
Whatcom +MMF <sup>c</sup>	176 (7.4)	4.23 (2.31, 7.74)*	68	55
Whitman	10 (0.4)		0 (0)	0 (0)

Yakima	140 (5.9)	2 (0.50, 8.00)	9 (3.3)	6 (3.9)
--------	-----------	----------------	---------	---------

<sup>a</sup>Reported STEC cases with a county fair occurring in their county of residence in either the hazard or referent period.

<sup>b</sup>Reported STEC cases with a county fair occurring in their county of residence during the hazard period (1-7 days prior to symptom onset) and not the referent period.

<sup>c</sup>Includes the Milk Makers Festival in 2015 (Whatcom County) as a fair exposure

\* $p \leq 0.05$

**Table 3.** Odds ratios (ORs) and 95% confidence intervals of STEC infection stratified by age

<b>Age Group</b>	<b>OR (95% CI)</b>	<b>N (%) with discordant exposure<sup>a</sup></b>
All age groups	1.31 (1.02, 1.66)*	270 (100)
0-4	0.91 (0.57, 1.47)	69 (25.6)
5-9	1.47 (0.76, 2.83)	37 (13.7)
10-19	2.35 (1.33, 4.15)*	57 (21.1)
20-39	1.11 (0.66, 1.87)	33 (12.2)
40-59	1.25 (0.59, 2.67)	27 (10.0)
60+	1.30 (0.57, 2.96)	23 (8.5)

<sup>a</sup>Reported STEC cases with a county fair occurring in their county of residence in either the hazard or referent period.

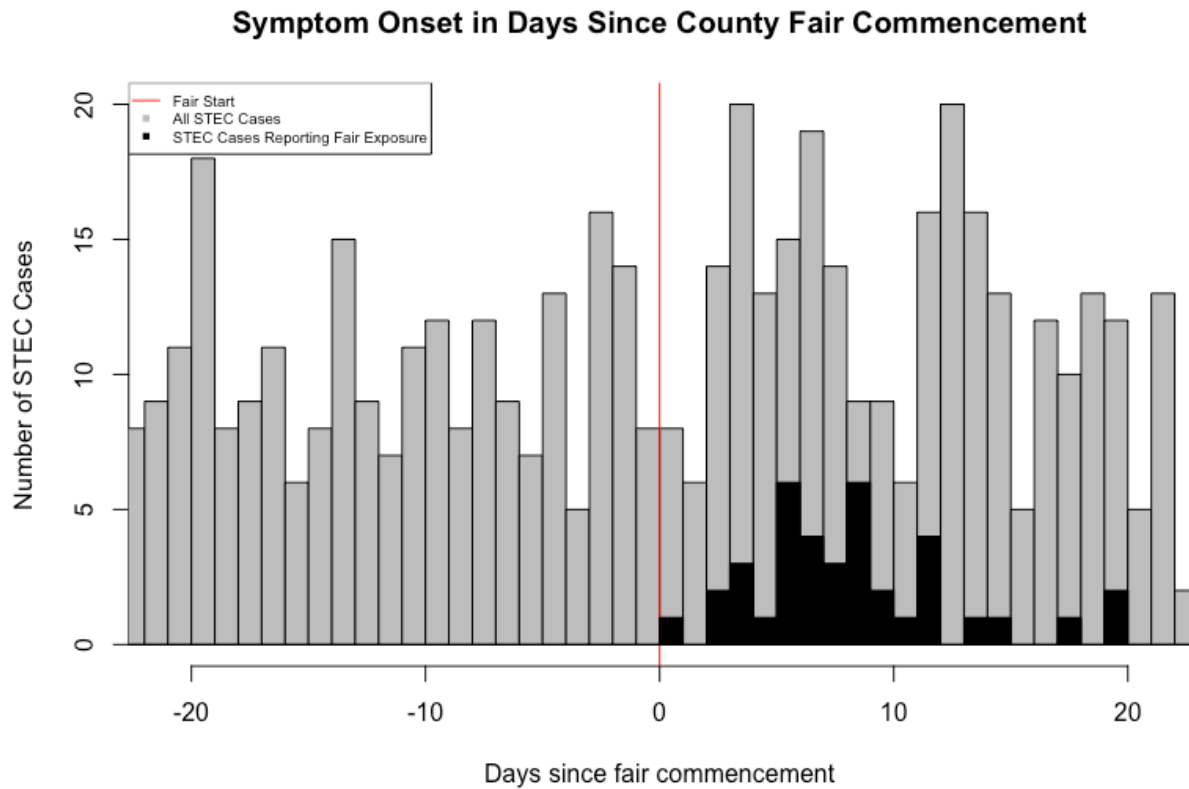
\* $p \leq 0.05$



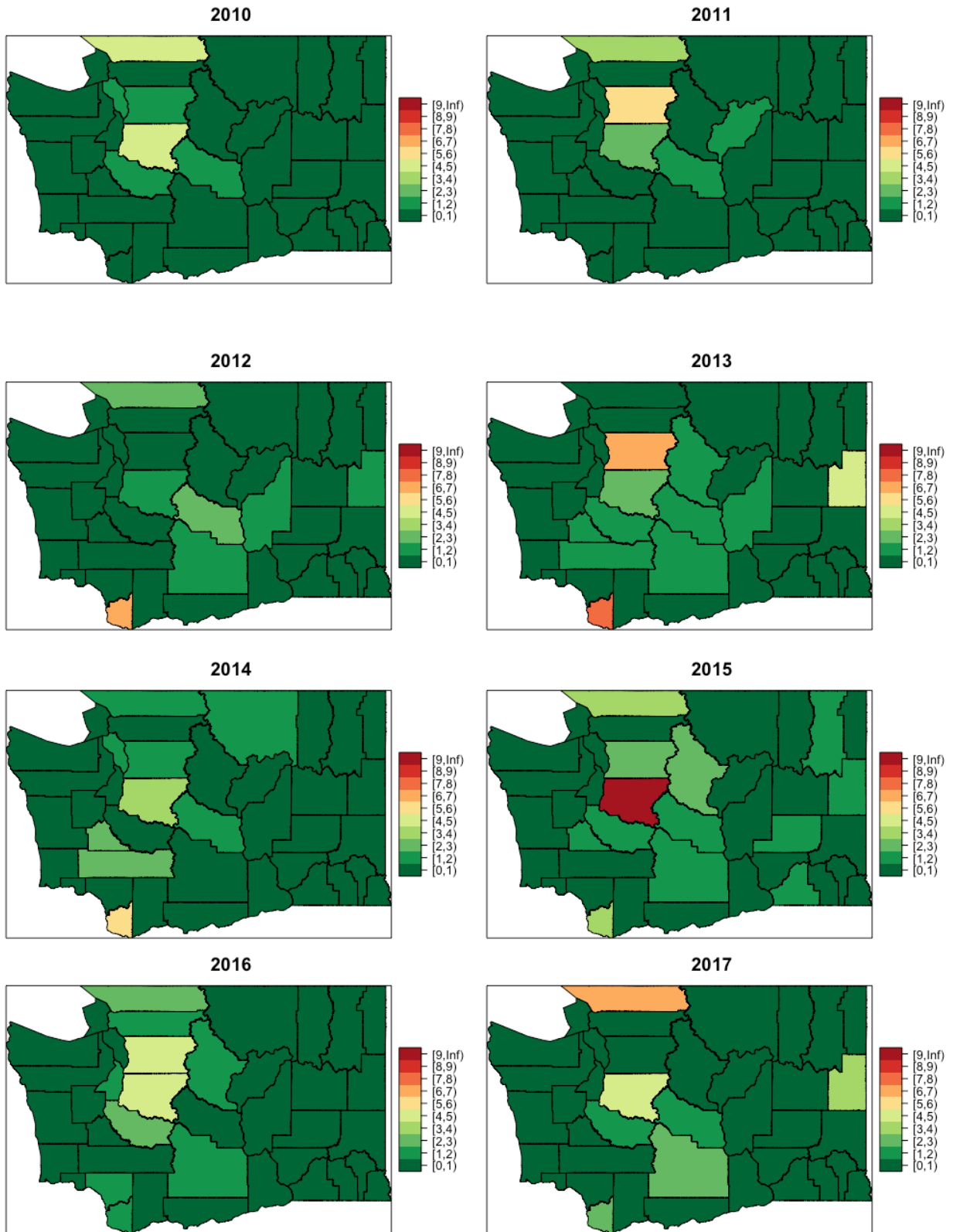


<b>Whatcom</b>	<b>Year</b>	<b>O157</b>	<b>O26</b>	<b>O121</b>	<b>O100</b>	<b>O103</b>	<b>O111</b>	<b>O153</b>	<b>O156</b>	<b>O183</b>	<b>O46</b>	<b>O69</b>	<b>O71</b>	<b>O80</b>	<b>O undetermined</b>
	2012	2													
	2014		1												
	2015	3													
	2017	4	1												
<b>Yakima</b>	2012	1													
	2013	1													
	2015								1						
	2016					1									
	2017	1													
<b>Total N (%)</b>		<b>78 (63.4)</b>	<b>19 (15.4)</b>	<b>7 (5.7)</b>	<b>1 (0.8)</b>	<b>4 (3.2)</b>	<b>3 (2.4)</b>	<b>1 (0.8)</b>	<b>3 (2.4)</b>	<b>1 (0.8)</b>	<b>1 (0.8)</b>	<b>1 (0.8)</b>	<b>1 (0.8)</b>	<b>1 (0.8)</b>	<b>2 (1.6)</b>

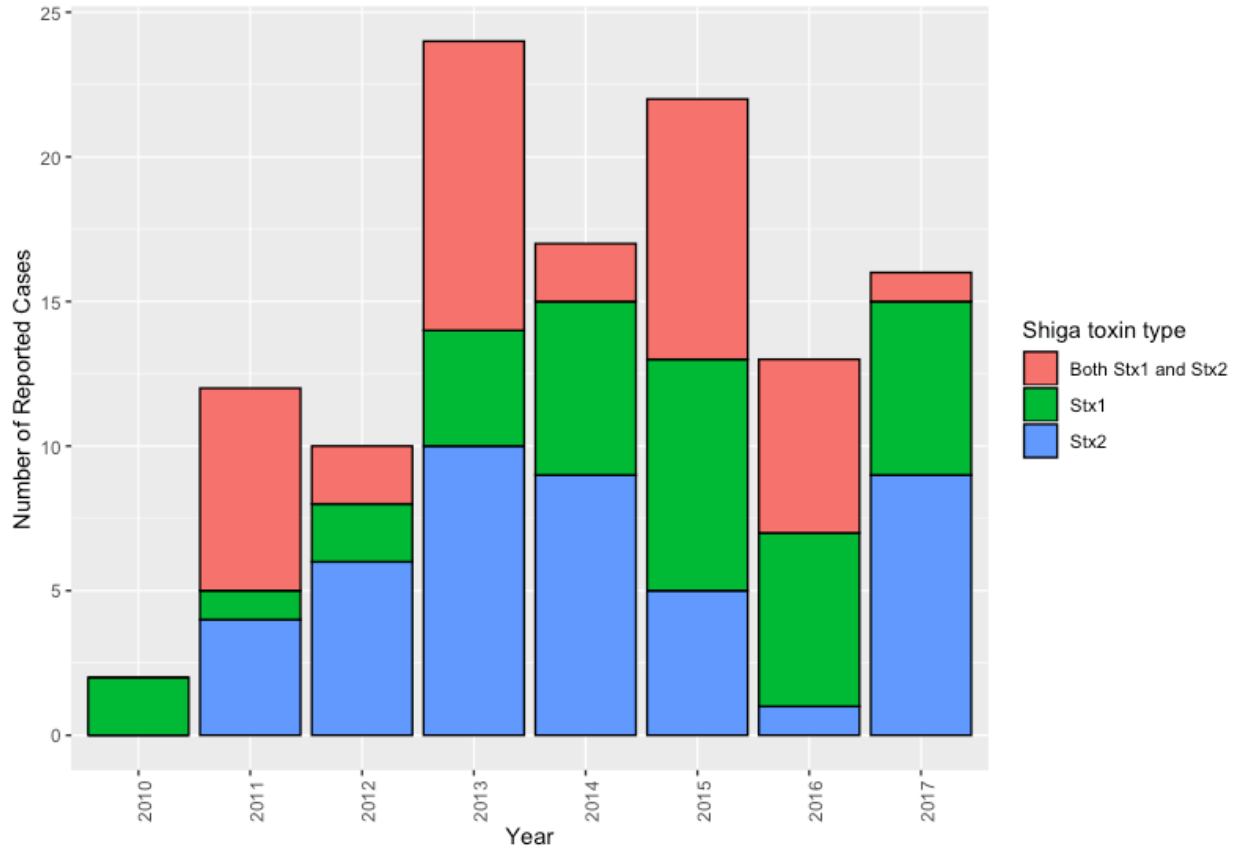
## Figures



**Figure 1.** Reported STEC cases plotted by the difference between their symptom onset date and the first day of a county fair within their county of residence, combined across all years in the study (2010-2017). STEC case patients who reported attending a county fair during their exposure period are highlighted in black.



**Figure 2.** The number of STEC cases reported within seven days of a county fair mapped by county and year (2010-2017) in Washington State.



**Figure 3.** Frequency of Shiga toxin types of reported STEC cases occurring within seven days of a county fair between 2010-2017.

## References

- Angulo, F.J., Steinmuller, N., Demma, L., Bender, J.B., & Eidson, M. (2006). Outbreaks of enteric disease associated with animal contact: Not just a foodborne problem anymore. *Clinical Infectious Diseases*, 43(12):1596-1602.
- Bettelheim, K.A. (2007). The non-O157 shiga-toxigenic (verocytotoxigenic) *Escherichia coli*; under-rated pathogens. *Critical Reviews in Microbiology*, 33(1):67-87.
- Bonardi, S., Alpigiani, I., Tozzoli, R., Vismarra, A., Zecca, V., Greppi, C., Bacci, C., Bruini, I., & Brindani, F. (2015). Shiga toxin-producing *Escherichia coli* O157, O26, and O111 in cattle faeces and hides in Italy. *Vet Record Open*, 2(1).
- Brandal, L.T., Wester, A.L., Lange, H., Lobersli, I., Lindstedt, B., Vold, L., & Kapperud, G. (2015). Shiga toxin-producing *Escherichia coli* infections in Norway, 1992-2012: characterization of isolates and identification of risk factors for haemolytic uremic syndrome. *BMC Infectious Diseases*, 15:324. doi: 10.1186/s12879-015-1017-6.
- Brooks, J.T., Sowers, E.G., Wells, J.G., Greene, K.D., Griffin, P.M., Hoekstra, R.M., & Strockbine, N.A. (2005). Non-O157 Shiga toxin-producing *Escherichia coli* infections in the United States, 1983-2002. *The Journal of Infectious Diseases*, 192(8):1422-1429.
- Centers for Disease Control and Prevention (2005). Outbreaks of *Escherichia coli* O157:H7 associated with petting zoos ---North Carolina, Florida, and Arizona, 2004 and 2005. *MMWR*, 54(50):1277-1280.
- Centers for Disease Control and Prevention (2009). Recommendations for diagnosis of Shiga toxin-producing *Escherichia coli* Infections by clinical laboratories. *MMWR*, 58 (RR12); 1-14.
- Centers for Disease Control and Prevention (2011). Notes from the field: *Escherichia coli* O157:H7 gastroenteritis associated with a state fair – North Carolina. *MMWR*, 60(51):1745-1746.
- Centers for Disease Control and Prevention (2015). Outbreak of *Escherichia coli* O157:H7 infections associated with dairy education event attendance - Whatcom County, Washington. *MMWR*, 64(42):1202-1203.
- Centers for Disease Control and Prevention (2019). *E. coli* (*Escherichia coli*). Retrieved from <https://www.cdc.gov/ecoli/general/index.html>.
- Charatan, F. (1999). New York outbreak of *E. coli* poisoning affects 1000 and kills two. *BMJ*, 319(7214):873.
- Cho, S., Diez-Gonzalez, F., Fossler, C.P., Wells, S.J., Hedberg, C.W., Kaneene, J.B., Ruegg, P.L., Warnick, L.D., & Bender, J.B. (2006). Prevalence of shiga toxin-encoding bacteria and

shiga toxin-producing *Escherichia coli* isolates from dairy farms and county fairs. *Veterinary Microbiology*, 118(3-4):289-298.

Council of State and Territorial Epidemiologists (2013). Update to Public Health Reporting for Shiga toxin-producing *Escherichia coli* (STEC). Retrieved from <https://cdn.ymaws.com/www.cste.org/resource/resmgr/PS/13-ID-01.pdf>

Crump, J.A., Braden, C.R., Dey, M.E., Hoekstra, R.M., Rickelman-Apisa, J.M., Bladwin, D.A., De Fijter, S.J., Nowicki, S.F., Koch, E.M., Bannerman, T.L., Smith, F.W., Sarisky, J.P., Hochberg, N., & Mead, P.S. (2003). Outbreaks of *Escherichia coli* O157 infections at multiple county agricultural fairs: a hazard of mixing cattle, concession stands and children. *Epidemiology & Infection*, 131(3):1055-1062.

Dawson, D.E., Keung, J.H., Napoles, M.G., Vella, M.R., Chen, S., Sanderson, M.W., & Lanzas, C. (2018). Investigating behavioral drivers of seasonal Shiga-toxigenic *Escherichia coli* (STEC) patterns in grazing cattle using an agent-based model. *PLoS One*, 13(10):e0205418.

Dewsbury, D.M.A., Renter, D.G., Shridhar, P.B., Noll, L.W., Shi, X., Nagaraja, T.G., & Cerniccharo, N. (2015). Summer and winter prevalence of Shiga toxin-producing *Escherichia coli* (STEC) O26, O45, O103, O111, O121, O145, and O157 in feces of feedlot cattle. *Foodborne Pathogens and Disease*, 12(8):726-32.

Dixon, K.E. (1997). A comparison of case-crossover and case-control designs in a study of risk factors for hemorrhagic fever with renal syndrome. *Epidemiology*, 8(3):243-246.

Durso, L.M., Reynolds, K., Bauer, N., Jr., & Keen, J.E. (2005). Shiga-toxigenic *Escherichia coli* O157:H7 infections among livestock exhibitors and visitors at a Texas County Fair. *Vector-Borne and Zoonotic Diseases*, 5(2):193-201.

Erickson, M.C., Webb, C.C., Diaz-Perez, J.C., Phatak, S.C., Silvoy, J.J., Davey, L., Payton, A.S., Liao, J., Ma, L., & Doyle, M.P. (2010). Surface and internalized *Escherichia coli* O157:H7 on field-grown spinach and lettuce treated with spray-contaminated irrigation water. *Journal of Food Protection*, 73(6):1023-1029.

Erickson, M.C., Webb, C.C., Davey, L.E., Payton, A.S., Flitcroft, I.D., & Doyle, M.P. (2014). Biotic and abiotic variables affecting internalization and fate of *Escherichia coli* O157:H7 isolates in leafy green roots. *Journal of Food Protection*, 77(6):872-879.

Erickson, M.C., Liao, J.Y., Payton, A.S., Cook, P.W., & Ortega, Y.R. (2019). Survival and internalization of *Salmonella* and *Escherichia coli* O157:H7 sprayed onto different cabbage cultivars during cultivation in growth chambers. *Journal of the Science of Food and Agriculture*, 99(7):3530-3537.

Feder, I.F., Wallace, M.F., Gray, J.T., Fratamico, P., Fedorka-Cray, P.J., Pearce, R., Call, J., Perrine, R., & Luchansky, J.B. (2002). Isolation of *Escherichia coli* O157:H7 from intact colon fecal samples of swine. *Emerging Infectious Diseases*, 9:380-383.

Germinario, C., Caprioli, A., Giordano, M., Chironna, M., Gallone, M.S., Tafuri, S., Minella, F., Maugliani, A., Michelacci, A., Santangelo, L., Mongelli, O., Montagna, C., & Scavia, G. (2016). Community-wide outbreak of haemolytic uraemic syndrome associated with Shiga toxin 2-producing *Escherichia coli* O26:H11 in southern Italy, summer 2013. *Eurosurveillance*, 21(38): 30343.

Goode, B., O'Reilly, C., Dunn, J., Fullerton, K., Smith, S., Ghneim, G., Keen, J., Durso, L., Davies, M., & Montgomery, S. (2009). Outbreak of *Escherichia coli* O157: H7 infections after Petting Zoo visits, North Carolina State Fair, October-November 2004. *Archives of Pediatrics and Adolescent Medicine*, 163(1):42-48.

Hussein, H.S. (2007). Prevalence and pathogenicity of Shiga toxin-producing *Escherichia coli* in beef cattle and their products. *Journal of Animal Science*, 85(13): E63-72.

Hale, C.R., Scallan, E., Cronquist, A.B., Dunn, J., Smith, K., Robinson, T., Lathrop, S., Tobin-D'Angelo, M., & Clogher, P. (2012). Estimates of enteric illness attributable to contact with animals and their environments in the United States. *Clinical Infectious Diseases*, 54 Suppl 5:S472-479.

Hancock, D.D., Besser, T.E., Kinsel, M.L., Tarr, P.I., Rice, D.H., & Paros, M.G. (1994). The prevalence of *Escherichia coli* O157:H7 in dairy and beef cattle in Washington State. *Epidemiology & Infection*, 113(2):199-207.

Jay, M.T., Cooley, M., Carychao, D., Wiscomb, G.W., Sweitzer, R.A., Crawford-Miksza, L., Farrar, J.A., Lau, D.K., O'Connell, J., Millington, A., Asmundson, R.V., Atwill, E.R., & Mandrell, R.E. (2007). *Escherichia coli* O157:H7 in feral swine near spinach fields and cattle, Central California Coast. *Emerging Infectious Diseases*, 13(12): 1908-1911.

Karmali, M.A. (2018). Factors in the emergence of serious human infections associated with highly pathogenic strains of Shiga toxin-producing *Escherichia coli*. *International Journal of Medical Microbiology*, 308(8):1067-1072.

Keen, J.E., Wittum, T.E., Dunn, J.R., Bono, J.L., & Durso, L.M. (2006). Shiga-toxigenic *Escherichia coli* O157 in agricultural fair livestock, United States. *Emerging Infectious Diseases*, 12(5):780-786.

Luna-Gierke, R.E., Wymore, K., Sadlowski, J., Clogher, P., Gierke, R.W., Tobin-D'Angelo, M., Palmer, A., Medus, C., Nicholson, C., McGuire, S., Martin, H., Garman, K., Griffin, P.M., &

Mody, R.K. (2014). Multiple-aetiology enteric infections involving non-O157 Shiga toxin-producing *Escherichia coli*--FoodNet, 2001-2010. *Zoonoses and Public Health*, 61(7):492-498.

Maclure, M. & Mittleman, M.A. (2000). Should we use a case-crossover design? *Annual Review of Public Health*, 21: 193-221.

Mathusa, E.C., Chen, Y., Enache, & E., Hontz, L. (2010). Non-O157 Shiga toxin-producing *Escherichia coli* in foods. *Journal of Food Protection*, 73(9):1721-1736.

McNamara, S.E., Abdujamilova, N., Somsel, P., Gordoncillo, M.J., DeDecker, J.M., & Bartlett, P.C. (2011). Carriage of *Clostridium difficile* and other enteric pathogens among a 4-H avocational cohort. *Zoonoses and Public Health*, 58:192-199.

Mellor, G.E., Fegan, N., Duffy, L.L., McMillan, K.E., Jordan, D., & Barlow, R.S. (2016). National survey of Shiga toxin-producing *Escherichia coli* serotypes O26, O45, O103, O111, O121, O145, and O157 in Australian beef cattle feces. *Journal of Food Protection*, 79(11):1868-1874.

Melton-Cesla, A.R. (2014). Shiga toxin (Stx) classification, structure, and function. *Microbiology Spectrum*, 2(4).

Olsen, S.J., Miller, G., Breuer, T., Kennedy, M., Higgins, C., Walford, J., McKee, G., Fox, K., Bibb, W., & Mead, P. (2002). A waterborne outbreak of *Escherichia coli* O157:H7 infections and hemolytic syndrome: implications for rural water systems. *Emerging Infectious Diseases*, 8(4):370-375.

Pires, S.M., Majowicz, S., Gill, A., & Devleeschauwer, B. (2019). Global and regional source attribution of Shiga toxin-producing *Escherichia coli* infections using analysis of outbreak surveillance data. *Epidemiology & Infection*, 147:e236.

Rossez, Y., Holmes, A., Lodberg-Pederson, H., Birse, L., Marshall, J., Willats, W.G.T., Toth, I.K., & Holden, N.J. (2014). *Escherichia coli* common pilus (ECP) targets arabinosyl residues in plant cell walls to mediate adhesion to fresh produce plants. *The Journal of Biological Chemistry*, 289(49):34349-34365.

Roug, A., Byrne, B.A., Conrad, P.A., & Miller, W.A. (2013). Zoonotic fecal pathogens and antimicrobial resistance in county fair animals. *Comparative Immunology, Microbiology and Infectious Diseases*, 36:303-308.

Samadpour, M., Ongerth, J.E., Liston, J., Tran, N., Nguyen, D., Whittam, T.S., Wilson, R.A., & Tarr, P.I. (1994). Occurrence of Shiga-like toxin-producing *Escherichia coli* in retail fresh seafood, beef, lamb, pork, and poultry from grocery stores in Seattle, Washington. *Applied and Environmental Microbiology*, 60(3): 1038-1040.

Samadpour, M., Kubler, M., Buck, F.C., Depavia, G.A., Mazengia, E., Stewart, J., Yang, P., & Alfi, D. (2002). Prevalence of Shiga toxin-producing *Escherichia coli* in ground beef and cattle feces from King County, Washington. *Journal of Food Protection*, 65(8):1322-1325.

Sheng, H., Shringi, S., Baker, K.N.K., Minnich, S.A., Hovde, C.J., & Besser, T.E. (2015). Standardized *Escherichia coli* O157:H7 exposure studies in cattle provide evidence that bovine factors do not drive increased summertime colonization. *Applied and Environmental Microbiology*, 82(3):964-71.

Spickler, A.R. (2016). Enterohemorrhagic *Escherichia coli* Infections. Retrieved from <http://www.cfsph.iastate.edu/DiseaseInfo/factsheets.php>.

Steinmuller, N., Demma, L., Bender, J.B., Eidson, M., & Angulo, F.J. (2006). Outbreaks of enteric disease associated with animal contact: not just a foodborne problem anymore. *Clinical Infectious Diseases*, 43(12):1596-1602.

Stigi, K.A, MacDonald, J.K., Tellez-Marfin, A.A., & Lofy, K.H. (2012). Laboratory practices and incidence of non-O157 Shiga toxin-producing *Escherichia coli* infections. *Emerging Infectious Diseases*, 18(3):477-479

Swoveland, J.L., Stewart, L.K., Eckmann, M.K., Gee, R., Allen, K.J., Vandegrift, C.M., Olson, G., Kang, M.G., Tran, M.L., Melius, E., Hiatt, B., Gautom, R.K., & Perez-Osorio, A.C. (2019) Laboratory review of foodborne disease investigations in Washington State 2007-2017. *Foodborne Pathogens and Disease*, 16:513-523

Tseng, M., Fratamico, P.M., Manning, S.D., & Funk, J.A. (2014). Shiga toxin-producing *Escherichia coli* in swine: the public health perspective. *Animal Health Research Reviews*, 15(1): 63-75.

Varma, J.K., Greene, K.D., Reller, M.E., DeLong, S.M., Trottier, J., Nowicki, S.F., DiOrio, M., Koch, E.M., Bannerman, T.L., York, S.T., Lambert-Fair, M.A., Wells, J.G., & Mead, P.S. (2003). An outbreak of *Escherichia coli* O157 infection following exposure to a contaminated building. *The Journal of the American Medical Association*, 290(20):2709-2712.

Wonhee, C., Fratamico, P.M., Ruth, L.E., Bowman, A.S., Nolting, J.M., Manning, S.D., & Funk, J.A. (2018). Prevalence and characteristics of Shiga toxin-producing *Escherichia coli* in finishing pigs: Implications on public health. *International Journal of Food Microbiology*, 264(8): 8-15.

## Appendix



# Shiga toxin-producing Escherichia coli

County \_\_\_\_\_

Case name (last, first) \_\_\_\_\_  
 Birth date \_\_\_/\_\_\_/\_\_\_ Sex at birth  F  M  Other Alternate name \_\_\_\_\_  
 Phone \_\_\_\_\_ Email \_\_\_\_\_  
 Address type  Home  Mailing  Other  Temporary  Work  
 Street address \_\_\_\_\_  
 City/State/Zip/County \_\_\_\_\_  
 Residence type (incl. Homeless) \_\_\_\_\_ WA resident  Yes  No

## ADMINISTRATIVE

Investigator \_\_\_\_\_  
 LHJ Case ID (optional) \_\_\_\_\_  
 LHJ notification date \_\_\_/\_\_\_/\_\_\_  
 Classification  Classification pending  Confirmed  
 Not reportable  Probable  Ruled out  Suspect  
 Investigation status  
 In progress  
 Complete  
 Complete – not reportable to DOH  
 Unable to complete Reason \_\_\_\_\_  
 Investigation start date \_\_\_/\_\_\_/\_\_\_  
 Investigation complete date \_\_\_/\_\_\_/\_\_\_  
 Case complete date \_\_\_/\_\_\_/\_\_\_  
 Outbreak related  Yes  No  
 LHJ Cluster ID \_\_\_\_\_ Cluster Name \_\_\_\_\_

## DEMOGRAPHICS

Age at symptom onset \_\_\_\_\_  Years  Months  
 Ethnicity  Hispanic or Latino  Not Hispanic or Latino  Unk  
 Race (check all that apply)  Unk  Amer Ind/AK Native  
 Asian  Black/African Amer  Native HI/other PI  
 White  Other \_\_\_\_\_  
 Primary language \_\_\_\_\_  
 Interpreter needed  Yes  No  Unk  
 Employed  Yes  No  Unk  
 Occupation \_\_\_\_\_ Work site \_\_\_\_\_  
 Student/Day care  Yes  No  Unk  
 Type of school  Preschool/day care  K-12  College  
 Graduate School  Vocational  Online  Other  
 School name \_\_\_\_\_  
 School address \_\_\_\_\_  
 City/State/County \_\_\_\_\_ Zip \_\_\_\_\_  
 Phone number \_\_\_\_\_ Teacher's name \_\_\_\_\_

## REPORT SOURCE

Initial report source \_\_\_\_\_  
 LHJ \_\_\_\_\_  
 Reporter organization \_\_\_\_\_  
 Reporter name \_\_\_\_\_  
 Reporter phone \_\_\_\_\_  
 All reporting sources (list all that apply)  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

## COMMUNICATIONS

Primary HCP name \_\_\_\_\_  
 Phone \_\_\_\_\_  
 OK to talk to patient (If Later, provide date)  
 Yes  Later \_\_\_/\_\_\_/\_\_\_  Never  
 Date of interview attempt \_\_\_/\_\_\_/\_\_\_  
 Complete  Partial  Unable to reach  
 Patient could not be interviewed  
 Alternate contact  Parent/Guardian  Spouse/Partner  
 Friend  Other \_\_\_\_\_  
 Contact name \_\_\_\_\_  
 Contact phone \_\_\_\_\_

## CLINICAL INFORMATION

Complainant ill  Yes  No  Unk Symptom Onset \_\_\_/\_\_\_/\_\_\_  Derived Diagnosis date \_\_\_/\_\_\_/\_\_\_  
 Illness duration \_\_\_\_\_  Days  Weeks  Months  Years Illness is still ongoing  Yes  No  Unk

### Clinical Features

Signs and Symptoms

Y N Unk

**Diarrhea** (3 or more loose stools within a 24 hour period) Onset date \_\_\_/\_\_\_/\_\_\_

**Bloody diarrhea**

**Abdominal pain or cramps**

Nausea

Vomiting

Any fever, subjective or measured Temp measured?  Yes  No Highest measured temp \_\_\_\_\_°F

Complications

Acute anemia with microangiopathic changes (i.e., schistocytes, burr cells, or helmet cells) on peripheral blood smear)

Renal injury (hematuria, proteinuria, or elevated creatinine levels (i.e., greater than or equal to 1.0 mg/dL in a child aged less than 13 years or greater than or equal to 1.5 mg/dL in a person aged greater than or equal to 13 years, or greater than or equal to 50% increase over baseline)

**Y N Unk**

- Hemolytic Uremic Syndrome (HUS)** (*Anemia (acute onset) with microangiopathic changes (i.e., schistocytes, burr cells, or helmet cells) on peripheral blood smear, AND Renal injury (acute onset) evidenced by either hematuria, proteinuria, or elevated creatinine levels*)
- Thrombotic Thrombocytopenic Purpura (TTP)**
- Kidney dialysis as a result of illness
- Coagulopathy (platelets <100,000)
- Any other complication \_\_\_\_\_

**Predisposing Conditions**

**Y N Unk**

- Antibiotic taken for this diarrheal illness
- Immunosuppressive therapy or condition, or disease \_\_\_\_\_
- Other underlying medical conditions \_\_\_\_\_

**Hospitalization**

**Y N Unk**

- Hospitalized at least overnight for this illness Facility name \_\_\_\_\_  
Hospital admission date \_\_\_/\_\_\_/\_\_\_ Discharge \_\_\_/\_\_\_/\_\_\_ HRN \_\_\_\_\_
- Still hospitalized As of \_\_\_/\_\_\_/\_\_\_
- Admitted to ICU Date admitted to ICU \_\_\_/\_\_\_/\_\_\_ Date discharged from ICU \_\_\_/\_\_\_/\_\_\_

**Y N Unk**

- Died of this illness Death date \_\_\_/\_\_\_/\_\_\_ *Please fill in the death date information on the Person Screen*

**RISK AND RESPONSE (Ask about exposures 1 to 8 days before symptom onset)**

**Travel**

	Setting 1	Setting 2	Setting 3
Travel out of:	<input type="checkbox"/> County/City _____ <input type="checkbox"/> State _____ <input type="checkbox"/> Country _____ <input type="checkbox"/> Other _____	<input type="checkbox"/> County/City _____ <input type="checkbox"/> State _____ <input type="checkbox"/> Country _____ <input type="checkbox"/> Other _____	<input type="checkbox"/> County/City _____ <input type="checkbox"/> State _____ <input type="checkbox"/> Country _____ <input type="checkbox"/> Other _____
Destination name			
Start and end dates	___/___/___ to ___/___/___	___/___/___ to ___/___/___	___/___/___ to ___/___/___

**Risk and Exposure Information**

**Y N Unk**

- Does the case know anyone else with similar symptoms or illness  
Onset date, shared meals, relationship, etc. \_\_\_\_\_
- Contact with lab confirmed case
- Childcare/Daycare
- Household
- Sexual
- Other \_\_\_\_\_
- Attends childcare or preschool Location/details \_\_\_\_\_
- Contact with diapered or incontinent child or adult
- Visited, lived, or worked in a residential facility

**Dietary Information**

**Y N Unk**

- Special or restricted diet (medical, weight-loss, religious, cultural, vegetarian/vegan, allergies, etc.)  
 Kosher  Dairy-free  Halal  Gluten free  Raw foods  Vegetarian  Vegan  Weight control  
 Allergy to food  Other \_\_\_\_\_  
 Describe diet \_\_\_\_\_
- Select mostly organic products  
 Produce  Other products

**Food Exposure - Food exposure timeframe: 1-8 days prior to onset of illness**

Sources of food

	Name, location, dates shopped	Name, location, dates shopped
Ethnic specialty markets		
Farmer's markets or purchases at a farm		
Grocery store or supermarket		
Health food; Co-op; Fish or meat specialty shop		
School or institution		

	Name, location, dates shopped	Name, location, dates shopped
Small or mini market, convenience store		
Warehouse store		
Other		
Other		

**Y M N Unk**

- During food exposure timeframe, did you eat food outside the home (including take-out)
- Restaurant (type: Asian; BBQ/Steak/Grill; Breakfast/Brunch/Diner; Chinese; Fast food; French; Indian; Italian; Jamaican/Cuban/Caribbean; Mexican; Middle Eastern/Arabic/Lebanese; Seafood; Sushi; Vegetarian/Vegan; Other)

Name, location	Date and time (mm/dd/yyyy ##:## AM/PM)	Foods eaten	Type (see list above)

**Y M N Unk**

**Details**

- Catered Events \_\_\_\_\_
- School or institution meal \_\_\_\_\_
- Group meal (e.g., potluck, reception) \_\_\_\_\_
- Street-vended food \_\_\_\_\_
- Any food sampled (grocery, warehouse stores, food court, etc.) \_\_\_\_\_
- Other \_\_\_\_\_

**Consumed any of the following during exposure period**

**Meat**

**Y M N Unk**

- Beef (e.g., ground, intact, raw)
- Ground beef (e.g., hamburger patties, meatloaf, casseroles, tacos) \_\_\_\_\_  
Date consumed \_\_\_/\_\_\_/\_\_\_
- Ate ground beef at home Purchase location/source \_\_\_\_\_
- Ate ground beef away from home Purchase location/source \_\_\_\_\_
- In what form(s) was the beef purchased  Bulk  Patties  Unk  Other \_\_\_\_\_
- Intact beef (e.g., steak, stew, roast, kebab or similar) \_\_\_\_\_  
Date consumed \_\_\_/\_\_\_/\_\_\_
- Ate intact beef at home Purchase location/source \_\_\_\_\_
- Ate intact beef away from home Purchase location/source \_\_\_\_\_
- Any raw beef dish (e.g., steak tartare, kitfo, carpaccio) \_\_\_\_\_

**Y M N Unk**

- Other meat (e.g., buffalo, wild game, goat)
- Buffalo/bison
- Venison, elk, boar, arctic mammal, or other wild game  
 Venison  Elk  Bear  Boar  Arctic mammal  Other wild game \_\_\_\_\_
- Other meat (e.g., goat, lamb) \_\_\_\_\_

**Other processed meat products**

**Y M N Unk**

- Other processed meat products (e.g., jerky, deli meats, sausage)
- Dried meat strips or jerky
- Dry/semi-dry ready to eat sausage such as salami, pepperoni, or summer sausage
- Deli-style meats
- Any fresh sausage  Chicken  Turkey  Pork  Beef  Other \_\_\_\_\_
- Any other meat products \_\_\_\_\_

**Miscellaneous meat exposure**

**Y M N Unk**

- Were any of the previously indicated meats/poultry consumed rare, undercooked, or raw  
 Goat  Lamb  Beef  Pork  Poultry  Wild game meat  Other \_\_\_\_\_
- Handled any raw meat, even if you did not eat it  
 Goat  Lamb  Beef  Pork  Poultry  Wild game meat  Other \_\_\_\_\_
- Ground beef present in the household even if not eaten

**Eggs and Dairy**

**Y M N Unk**

- Dairy (including cow, goat, sheep and other milk products)
- Milk (dairy or non-dairy) Type, variety or brand \_\_\_\_\_  
 Dairy animal type  Cow  Goat  Sheep  Other \_\_\_\_\_
- Raw/unpasteurized
- Any raw/unpasteurized milk left over
- Ate cheese from unpasteurized milk such as queso fresco or queso blanco Type/brand \_\_\_\_\_
- Any raw or homemade cheese left over
- Ate artisanal or gourmet cheese (e.g., from gourmet cheese section of grocery store, farmer's market, or cheese shop Type/brand \_\_\_\_\_
- Other unpasteurized dairy product (e.g., yogurt, kefir, ice cream) \_\_\_\_\_

**Produce**

**Y M N Unk**

Leafy greens (e.g., arugula, mesculun, spinach, lettuce)

	Fresh spinach	Iceberg lettuce	Romaine lettuce
Eaten at	<input type="checkbox"/> Home <input type="checkbox"/> Away from home	<input type="checkbox"/> Home <input type="checkbox"/> Away from home	<input type="checkbox"/> Home <input type="checkbox"/> Away from home
Type of leafy green eaten at home	<input type="checkbox"/> Pre-packaged/bagged <input type="checkbox"/> Loose/head <input type="checkbox"/> Shredded <input type="checkbox"/> Other _____	<input type="checkbox"/> Pre-packaged/bagged <input type="checkbox"/> Loose/head <input type="checkbox"/> Shredded <input type="checkbox"/> Other _____	<input type="checkbox"/> Pre-packaged/bagged <input type="checkbox"/> Loose/head <input type="checkbox"/> Shredded <input type="checkbox"/> Other _____
Eaten at home details (Purchase location/source/brand)			
Form of leafy green outside home	<input type="checkbox"/> On burger/sandwich/wrap <input type="checkbox"/> Salad/salad bar <input type="checkbox"/> Other _____	<input type="checkbox"/> On burger/sandwich/wrap <input type="checkbox"/> Salad/salad bar <input type="checkbox"/> Other _____	<input type="checkbox"/> On burger/sandwich/wrap <input type="checkbox"/> Salad/salad bar <input type="checkbox"/> Other _____

**Y M N Unk**

Other leafy green vegetables such as spring mix, field greens, baby greens, and gourmet salad mix  
 Type \_\_\_\_\_

**Y M N Unk**

Sprouts (e.g., alfalfa, bean, clover, broccoli, radish; including from a salad bar or on a sandwich)  
 Brand(s) \_\_\_\_\_ Purchase location(s) \_\_\_\_\_

- Alfalfa
- Bean (including Mung)
- Clover
- Broccoli
- Radish (including Daikon)
- Other \_\_\_\_\_

**Y M N Unk**

Fresh herbs (e.g., cilantro, basil, parsley, chives, mint)

- Cilantro
- Basil
- Parsley
- Sage
- Thyme
- Dill
- Chives
- Mint
- Oregano
- Other fresh herbs \_\_\_\_\_

**Y M N Unk**

- Fresh tomatoes
- Roma
- Cherry
- Grape
- Sold on the vine
- Red round

**Y M N Unk**

- Other \_\_\_\_\_
- Fresh tomatoes on a sandwich, burger, or salad \_\_\_\_\_
- Fresh tomato salsa or pico de gallo, not from a can/jar \_\_\_\_\_

**Y M N Unk**

- Other fresh produce \_\_\_\_\_
- Frozen vegetables \_\_\_\_\_

**Y M N Unk**

- Fresh fruit (e.g., berries, melons, citrus, tropical fruit)
- Berries \_\_\_\_\_
- Melons \_\_\_\_\_
- Tropical (e.g., kiwi, papaya, guava, pomegranate, mango, pineapple) \_\_\_\_\_
- Non-tropical tree fruit (e.g., apples, pears, peaches) \_\_\_\_\_
- Fresh citrus (including lemon/lime on a drink) \_\_\_\_\_
- Other fresh fruit \_\_\_\_\_
- Any pre-cut fruit \_\_\_\_\_

**Y M N Unk**

- Frozen fruit (e.g., berries, other) \_\_\_\_\_
- Frozen berries \_\_\_\_\_
- Other frozen fruit \_\_\_\_\_

*Drinks*

**Y M N Unk**

- Juices and Smoothies
- Smoothie  Fresh-made  Pre-packaged Describe \_\_\_\_\_
- Juice or cider Type \_\_\_\_\_
- Unpasteurized juices or cider Type \_\_\_\_\_
- Kombucha Describe \_\_\_\_\_
- Homemade

*Other Foods/Supplements*

**Y M N Unk**

- Nuts/seeds
- Any nuts  Peanuts  Almonds  Walnuts  Cashews  Pistachios  Hazelnuts/filberts  
 Other \_\_\_\_\_
- Peanut butter or peanut butter containing foods (e.g., peanut butter crackers)
- Nut butter or spread other than peanut butter (e.g., Nutella, almond butter, soy nut butter)
- Seeds or foods made from seeds  Sesame  Sunflower  Pumpkin  Chia  Flax  
 Halva  Other \_\_\_\_\_

**Y M N Unk**

- Vitamins, nutritional or herbal supplements (e.g., teas, tablets, pills) \_\_\_\_\_
- Drink powdered nutritional supplements \_\_\_\_\_
- Marijuana containing or infused products \_\_\_\_\_
- New or different foods or beverages consumed during the exposure \_\_\_\_\_

**Water Exposure**

**Y N Unk**

**Describe**

- Source of drinking water known
- Bottled water \_\_\_\_\_
- Public water system \_\_\_\_\_
- Individual well \_\_\_\_\_
- Shared well \_\_\_\_\_
- Other \_\_\_\_\_
- Untreated/unchlorinated water (e.g., surface, well, lake, stream, spring) \_\_\_\_\_
- Any recreational water exposure (e.g., lake, river, pool, waterpark) \_\_\_\_\_
- Water site name/location \_\_\_\_\_
- Treatment  Treated  Untreated  Unk
- Type  Lake  River  Pool/hot tub  Wading pool  Fountain  Waterpark  
 Splash pad/water playground  Other
- Describe \_\_\_\_\_

**Animal Exposure**

**Y N Unk**

- Any contact with pet animals at home or elsewhere
- Cats or kittens
- Dogs or puppies
- Any sick pets \_\_\_\_\_
- Any new household pets in the last month \_\_\_\_\_

**Y N Unk**

- Any contact with pet food or treats
- Raw pet food Type/variety/brand \_\_\_\_\_
- Pet treats or chews (pig ears, pizzles, rawhide, hooves, etc.) Type/variety/brand \_\_\_\_\_
- Prepackaged pet food (canned or dry) Type/variety/brand \_\_\_\_\_

**Y N Unk**

- Any contact with farm animals
- Cows or calves
- Donkeys
- Goats
- Horses or ponies
- Sheep
- Pigs or swine
- Baby chicks, ducklings or other baby poultry \_\_\_\_\_
- Adult chickens, turkeys, or other adult poultry \_\_\_\_\_
- Deer

**Y N Unk**

- Other animal contact \_\_\_\_\_
- Applied or handled compost/manure
- Contact with animal manure/droppings other than dogs or cats \_\_\_\_\_

*Animal Settings*

**Y N Unk**

- Live on a farm or other setting that has farm animals \_\_\_\_\_
- Household member works with animals \_\_\_\_\_
- Hunting/butchering \_\_\_\_\_
- Work with animals or animal products (e.g., research, farming, veterinary medicine, animal slaughter)

*Exposure to any of the following facilities/settings even if no direct animal contact*

	<b>Y N Unk</b>	<b>Describe</b>	<b>Type of exposure</b>
Research facility	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		<input type="checkbox"/> Work <input type="checkbox"/> Visit
Slaughterhouse	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		<input type="checkbox"/> Work <input type="checkbox"/> Visit
Veterinary facility	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		<input type="checkbox"/> Work <input type="checkbox"/> Visit

*Visited or worked on any of the following settings even if no direct animal contact*

	<b>Y N Unk</b>	<b>Location, animals, etc.</b>	<b>Type of exposure</b>
Petting zoo	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		<input type="checkbox"/> Work <input type="checkbox"/> Visit
Zoo	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		<input type="checkbox"/> Work <input type="checkbox"/> Visit
Dairy farm	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		<input type="checkbox"/> Work <input type="checkbox"/> Visit
Other farm contact	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		<input type="checkbox"/> Work <input type="checkbox"/> Visit
Agricultural 'Farm and Feed' store	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		<input type="checkbox"/> Work <input type="checkbox"/> Visit
County/state fairs, 4-H events, or similar events where animals are present	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		<input type="checkbox"/> Work <input type="checkbox"/> Visit
Pet store or other places where animals are sold or adopted	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		<input type="checkbox"/> Work <input type="checkbox"/> Visit
Attended any school events, birthday parties, or similar events with animals/pets	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		<input type="checkbox"/> Work <input type="checkbox"/> Visit
Other setting with animals Describe _____	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		<input type="checkbox"/> Work <input type="checkbox"/> Visit

**Sexual Exposure**

**Y N Unk**

Any type of sexual contact with others during the exposure period  
Number of sexual partners during exposure period \_\_\_\_\_ Female \_\_\_\_\_ Male

**Exposure and Transmission Summary**

**Y N Unk**

**Epi-linked to a confirmed or probable case**  
   Known contaminated food product \_\_\_\_\_  
   Outbreak related  
Likely geographic region of exposure  In Washington – county \_\_\_\_\_  Other state \_\_\_\_\_  
 Not in US - country \_\_\_\_\_  Unk  
International travel related  During entire exposure period  During part of exposure period  No international travel

**Public Health Issues**

**Y N Unk**

Employed as a food handler  
   Non-occupational food handling (e.g., potlucks, receptions) during contagious period  
   Employed as a health care worker  
   Employed in childcare or preschool  
   Attends childcare or preschool  
   Household member or close contact in sensitive occupation or setting (HCW, childcare, food)  
   Employed in or resident of long-term care facility

**Public Health Interventions/Actions**

**Y N Unk**

Exclude individuals in sensitive occupations or settings (HCW, food, child-care) until 2 negative stools  
Case cleared  2 negative labs  Health officer approved  Other \_\_\_\_\_  
   Test close contacts in sensitive occupations or situations  
   Hygiene education provided Date \_\_\_/\_\_\_/\_\_\_  
   Restaurant inspection Name/location \_\_\_\_\_  
   Childcare inspection  
   Testing of home/other water supply  
   Food testing  
   Commercial product implicated  
   Initiate trace-back investigation  
   Investigation of raw milk dairy  
   Letter sent Date \_\_\_/\_\_\_/\_\_\_ Batch date \_\_\_/\_\_\_/\_\_\_  
   Any other public health action

**TREATMENT**

**Note:** Antibiotics are not recommended for treating this disease

**Y N Unk**

Did patient receive prophylaxis/treatment  
Specify antibiotic \_\_\_\_\_  
Treatment start date \_\_\_/\_\_\_/\_\_\_ Treatment end date \_\_\_/\_\_\_/\_\_\_  
Prescribed duration \_\_\_\_\_  Days  Weeks  Months

**NOTES**

**LAB RESULTS**

Lab report information

**Lab report reviewed – LJH**

WDRS user-entered lab report note

Submitter \_\_\_\_\_  
Performing lab for entire report \_\_\_\_\_  
Referring lab \_\_\_\_\_

Specimen

**Specimen identifier/accession number** \_\_\_\_\_  
**Specimen collection date** \_\_\_/\_\_\_/\_\_\_ **Specimen received date** \_\_\_/\_\_\_/\_\_\_

**WDRS specimen type** \_\_\_\_\_  
WDRS specimen source site \_\_\_\_\_  
WDRS specimen reject reason \_\_\_\_\_

Test performed and result

**WDRS test performed** \_\_\_\_\_  
**WDRS test result, coded** \_\_\_\_\_

WDRS test result, comparator \_\_\_\_\_  
**WDRS result, numeric only** (enter only if given, including as necessary **Comparator** and **Unit of measure**) \_\_\_\_\_  
WDRS unit of measure \_\_\_\_\_

Test method \_\_\_\_\_  
WDRS interpretation code \_\_\_\_\_

Test result – Other, specify \_\_\_\_\_  
**WDRS result summary**  Positive  Negative  Indeterminate  Equivocal  Test not performed  Pending

- Test result status  Final results; Can only be changed with a corrected result
- Preliminary results
- Record coming over is a correction and thus replaces a final result
- Results cannot be obtained for this observation
- Specimen in lab; results pending

Result date \_\_\_/\_\_\_/\_\_\_

**Upload document**

Ordering Provider  
WDRS ordering provider \_\_\_\_\_

Ordering facility  
WDRS ordering facility name \_\_\_\_\_