3.3 Verotoxigenic *E. coli*

Summary

Number of VTEC cases, 2016: 839
Crude incidence rate, 2016: 17.6/100,000
Number of VTEC-associated HUS, 2016: 32
Number of VTEC cases, 2015: 730

For many years, Ireland has the highest verotoxigenic *Escherichia coli* (VTEC) notification rate in Europe, with the exception of 2011 when Germany reported the highest rate due to a large VTEC O104 outbreak linked with fenugreek seeds.[1-2] In 2015 (the most recent data available), the notification rate for confirmed VTEC cases in the European Union/European Economic Area was 1.33 per 100,000 (similar to 2014; 1.56/100,000) and the highest country-specific rates were in Ireland, the Netherlands and Norway (12.9, 5.1 and 4.3 per 100,000 population, respectively).[3]

The dominant transmission routes reported for VTEC infection in Ireland have been person-to-person spread, especially in childcare facilities and among families with young children, and waterborne transmission associated with exposure to water from untreated or poorly treated private water sources.[4-8] Other important transmission routes identified internationally include food (often minced beef products or fresh produce such as lettuce and spinach), and contact with infected animals or contaminated environments.[2, 9-10]

Materials and Methods

Infection with verotoxigenic *E. coli* became a notifiable disease in 2012; prior to that, VTEC had been notifiable under the category Enterohaemorrhagic *E. coli* (EHEC) since 2004. Enhanced epidemiological information was supplied as in previous years by HSE personnel, and the VTEC National Reference Laboratory at the Public Health Laboratory, Cherry Orchard Hospital Dublin (VTEC-NRL at PHL) provided VTEC confirmation and typing data. Data from all sources are maintained in the Computerised Infectious Disease Reporting (CIDR) system. Outbreaks of VTEC are notifiable since 2004 and these data are reported to CIDR by the eight regional Departments of Public Health.
Data from the Central Statistics Office (CSO) 2016 census were used to provide denominators for the calculation of national, regional and age-specific incidence rates in 2016.

Results

Incidence

In 2016, 839 cases of VTEC were notified in Ireland, equating to a crude incidence rate (CIR) of 17.6 per 100,000 (95% CI 16.4-18.8). Compared with 2015 (15.9 per 100,000) there was a 15% increase in the incidence of VTEC. Of the 839 VTEC notifications in 2016, 740 (88%) were classified as confirmed cases, 96 (11%) as probable cases and three as possible cases. The criteria under which notified cases were reported in 2016 are outlined in Table 1. As the classification of VTEC cases changed significantly upon the amendment of the Irish VTEC case definition in 2012, it is not valid to directly compare the number of notifications by case classification before 2012.

Of the 832 cases with laboratory evidence of infection, 697 were culture confirmed (268 with VTEC O26 and 174 with VTEC O157, with the remaining 255 caused by other serogroups), 135 were confirmed by PCR but were culture negative (includes 7 in which genes for serogroup O26

Table 1. Number of VTEC notifications by criteria for notification and case classification, Ireland, 2016

Notification criteria	Confirmed	Probable	Possible	Total
Laboratory confirmation by culture[a]	623	74		**697**
Laboratory confirmation by PCR only[b]	117	18		**135**
Reported solely on the basis of epidemiological link		4		**4**
Clinical HUS not meeting lab or epi criteria			3	**3**
Total	**740**	**96**	**3**	**839**

[a] Symptomatic culture confirmed cases are classified as confirmed cases, while asymptomatic culture confirmed cases are classified as probable cases
[b] Symptomatic PCR-confirmed cases are classified as confirmed cases, while asymptomatic PCR-confirmed cases are classified as probable cases

detected and 10 in which genes for serogroup O157 detected) (Tables 1 and 2). Until 2012, VTEC O157 were more commonly reported in Ireland than other serogroups; this trends was reversed since then with VTEC O157 accounting for just a quarter of notified cases in 2016 (Figure 1). VTEC O26 is now the most common serogroup reported accounting for almost 40% of cases in 2016. The crude incidence rate for VTEC O26 infections stands at 5.78/100,000 and for O157 stands at 3.86 per 100,000.

Severity of illness

Of the 839 notified cases in 2015, 713 (85%) were symptomatic. Among symptomatic cases (and where information available), 675/700 (91%) reported diarrhoea, 246/641 (38%) reported vomiting, 200/597 (34%) reported fever, 247/533 (46%) reported nausea, 425/600 (71%) reported abdominal pain and 261/666 (39%) developed bloody diarrhoea. Thirty two individuals developed HUS (3.8% of all notifications; 4.5% of symptomatic cases). This is the highest number of HUS cases since 2012 (n=33).

In 2016, 313 VTEC cases were hospitalised (38% of all notified cases; 42% of symptomatic). Six deaths occurred among VTEC cases, however none of these deaths was attributed to VTEC infection.

Of the 32 HUS cases, 12 were culture confirmed with *E. coli* O26, seven with *E. coli* O157, two with *E. coli* O145, one each

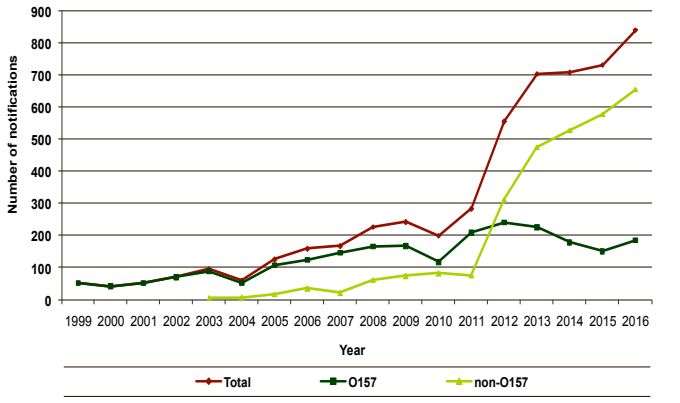

Figure 1. Annual number of confirmed and probable VTEC cases by serogroup, Ireland 1999-2016
Note: For simplicity in this figure, cases with mixed VTEC O157/other serogroup infections are included in the data for O157, as are probable cases linked to known E. coli O157 outbreaks. Non-O157 data includes cases with mixed non-O157 infections and probable cases linked to known O26 outbreaks

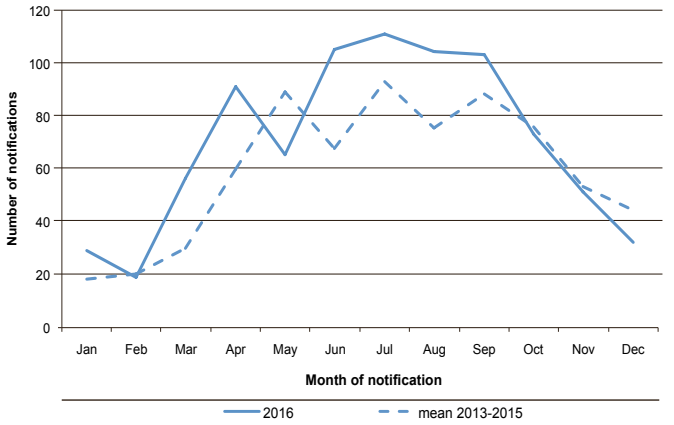

Figure 2. Seasonal distribution of the number of VTEC notifications in Ireland, 2016 and the mean of 2013-2015

Table 2. Number of VTEC notifications by serogroup, verotoxin and HUS status, Ireland, 2016

	Serogroup[a]	Verotoxin	HUS	non-HUS	Total	% with HUS
Laboratory confirmation by culture	O26	*vt1*	0	81	81	0%
		vt2	4	8	12	33%
		vt1+vt2	8	166	174	4.6%
		Not reported	0	1	1	0.0%
	O157	*vt1*	0	0	0	0.0%
		vt2	4	95	99	4.0%
		vt1+vt2	3	69	72	4.2%
		Not reported	0	3	3	0.0%
	Other	*vt1*	1	99	100	1.0%
		vt2	6	88	94	6.4%
		vt1+vt2	0	53	53	1.9%
		Not reported	0	8	8	0%
Laboratory confirmation by PCR only		*vt1*	0	45	45	0%
		vt2	3	54	57	5.3%
		vt1+vt2	0	29	29	0.0%
		Not reported	0	4	4	0.0%
Reported solely on the basis of epidemiological link		-	0	4	4	0.0%
Clinical HUS not meeting lab or epi criteria		-	3	0	3	100%
Total		**-**	**32**	**807**	**839**	**3.8%**

[a]For simplicity mixed infections were recorded as O157 if at least one strain was O157, as O26 if at least one strain was O26 but not O157, and as Other if only non-O157 or non-O26 strains were detected.

with *E. coli* O182, O2, O113, O103, and O148. Three were reported on the basis of a PCR positive result without culture confirmation and three were possible cases (i.e. clinical HUS, without meeting laboratory or epidemiological criteria).
HUS cases ranged in age from 1 month to 80 years and 69% (n=22) were in children under 15 years of age. Twenty-two of the HUS cases were considered sporadic, seven were part of family outbreaks and three were part of general outbreaks.

Seasonal distribution

Figure 2 shows the seasonal distribution of notifications in 2016 relative to the mean monthly number of cases in the years 2013-2015. Two peaks were observed in 2016; a smaller peak in April with a larger more protracted peak from June to October. As in previous years [19], VTEC O26 cases were more prevalent in the April-June period with VTEC O157 being more prevalent in July to October; infections due to all serogroups were uncommon in winter months (Figure 3).

Regional distribution

In 2016, the highest VTEC incidence rates were reported in the HSE-M and the HSE-MW. The rates were also significantly higher than the national crude incidence rate in the HSE-S, -SE and –W (Table 3). The incidence rates of VTEC in HSE-E, HSE-NE and HSE-NW were significantly lower than the national crude incidence rate. The highest incidence of VTEC-associated HUS was in HSE-MW and HSE-W (Table 3).

In the HSE areas except the HSE-E, the incidence of *E. coli* O26 in 2016 exceeded or equaled that of *E. coli* O157 (Figure 4).

Age-sex distribution

As in previous years, the highest reported age-specific incidence rate in 2016 was in the 0-4 year age group (94.7 per 100,000) (Figure 5).

Laboratory typing

In 2016, serogroup (culture positives only) and the verotoxin profiles of VTEC isolates/samples referred to the VTEC-NRL at PHL, Cherry Orchard Hospital are presented in Table 4. The most common serogroup reported among culture positive notifications was *E. coli* O26 (n=268), followed by *E. coli* O157 (n=174). Among the other serogroups listed by the World Health Organisation as having the highest association with HUS internationally, there were 45 *E. coli* O145, 12 *E. coli* O103 cases and 11 *E. coli* O111. Other serogroups with significant numbers of cases in 2016 included O91, O146 and O182.

As usual among *E. coli* O157 cases in Ireland, isolates containing the genes for *vt2* were more common (57%) than strains containing genes for both *vt1* and *vt2,* although a higher proportion of vt1 and vt2- containing strains of VTEC O157 were reported than in 2015. Among the VTEC O26 strains, those containing the genes for both *vt1* and *vt2* accounted for the majority (65%), followed by *vt1* only (30%) and those containing *vt2* making up the remaining 4% of *E. coli* O26 cases (Table 4).

Risk factors

Under the enhanced surveillance system for VTEC, risk factor information is routinely collected on all notifications (Table 5). Exposure to farm animals or their faeces and exposure to private well water were relatively common among cases in 2016; 38% and 44% reported these exposures, respectively. According to CSO data, in the general population, around 10.6% of households are served by private wells, indicating

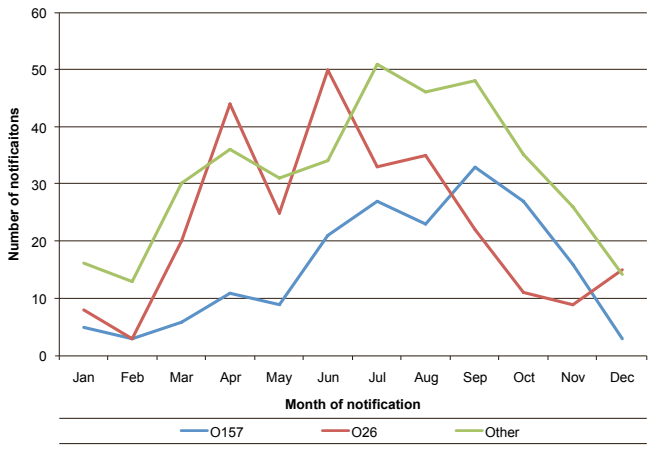

Figure 3: Seasonal distribution of VTEC notifications by serogroup, Ireland, 2016
For simplicity mixed infections were recorded as O157 if at least one strain was O157, as O26 if at least one strain was O26 but not O157, and as Other if only non-O157 or non-O26 strains were detected.

Table 3. Number and crude incidence rate VTEC by HSE area, and number and crude incidence rate of VTEC-associated HUS by HSE area, Ireland, 2016

HSE-area	Number of VTEC cases	Crude incidence rate /100,000 (95% CI)	Number HUS cases	Incidence of HUS /100,000 (95% CI)
E	131	7.7 (6.3-9.0)	4	0.2 (0.0-0.5)
M	92	32 (25-38)	1	0.3 (-0.3-1.0)
MW	124	32 (27-38)	7	1.8 (0.5-3.2)
NE	52	11 (8.2-14)	4	0.9 (0.0-1.7)
NW	31	12 (7.8-16)	1	0.4 (-0.4-1.1)
S	159	23 (19-27)	5	0.7 (0.1-1.4)
SE	131	26 (21-30)	4	0.8 (0.0-1.6)
W	119	26 (22-31)	6	1.3 (0.3-2.4)
IE	839	18 (16-19)	32	0.7 (0.4-0.9)

that, on a national basis, exposure to private wells appears to be more common among VTEC cases than among the general population. Unlike salmonellosis, foreign travel plays only a minor role in VTEC infection in Ireland, with the majority of infections acquired indigenously (96%). Where the information was available, just under a fifth of VTEC cases in 2016 were attending a childcare facility (CCF). When these analyses were restricted to notified VTEC under five years of age, 45% reported attendance at a childcare facility. This is similar to the proportion of children in the general population who use non-parental childcare (42%) as reported by the Central Statistics Office.[11]

Outbreak and environmental investigations

The outbreak surveillance system plays a key role in our understanding of the transmission of VTEC infection in Ireland. Ninety-eight VTEC outbreaks were notified in 2016, which included 250 of the 839 VTEC notifications. Forty-six outbreaks were due to *E. coli* O26, 21 to *E. coli* O157, 14 were mixed *E. coli* strain outbreaks, and 17 were caused by other VTEC strains.

The majority of outbreaks (n=91, 93%) were family outbreaks, with seven general outbreaks also notified. The 91 family outbreaks resulted in 175 persons becoming ill, with 30 hospitalised. The seven general outbreaks resulted in 52 persons becoming ill, with eight hospitalised. Eighty-four outbreaks occurred in private homes, six involved extended families, five involved childcare facilities, and there was one outbreak each in the community, associated with a pet farm (family outbreak) and associated with a restaurant. The suspected modes of transmission are listed in Table 6.

Person-to-person spread is consistently the most common mode of VTEC transmission reported in Ireland, particularly between young children, and was suspected to have played a role in 42 (56%) VTEC outbreaks in 2016 in which 107 persons were reported ill (Table 6 and Figure 5). Thirty-three of these outbreaks were reported as being solely due to person-to-person transmission, including four outbreaks which occurred in CCFs.

Waterborne transmission was reported to have contributed to 11 outbreaks (11%) with 29 persons ill.
This is lower than the number of waterborne VTEC outbreaks reported in 2015 (n=19) and 2012 (n=21) but similar to the number reported in 2013 (n=8) and 2014 (n=9) (Figure 6). Of the 11 outbreaks with links to waterborne transmission, ten were family outbreaks and one an extended family outbreak. At least nine outbreaks were associated with exposure to private wells; in five cases, the water quality was reported to be unsatisfactory.

Animal/environmental contact was reported to have contributed to 13 outbreaks (13%) with 22 persons ill (Figure 6). All were linked with private houses.

Three outbreaks were reported where food was believed to have contributed to transmission. Two were family outbreaks, while one general outbreak was reported associated with a restaurant. During the general outbreak investigation,eleven outbreak-related cases were identified, four of whom were hospitalised. Epidemiological, environmental and microbiological findings pointed to the serving of undercooked burgers as the likely cause.

For 39% (n=38) of VTEC outbreaks in 2015, the transmission route was reported as unknown (Table 6 and Figure 6).

Summary

The number of VTEC notifications in Ireland continued to rise in 2016. Within the European Union, Ireland continues to have the highest incidence rate for VTEC, reporting over seven times the European average in 2015.[3]

The upward trend observed in Ireland in recent years of non-O157 notifications continued in 2016 and reflects the more widespread use by the primary hospital laboratories

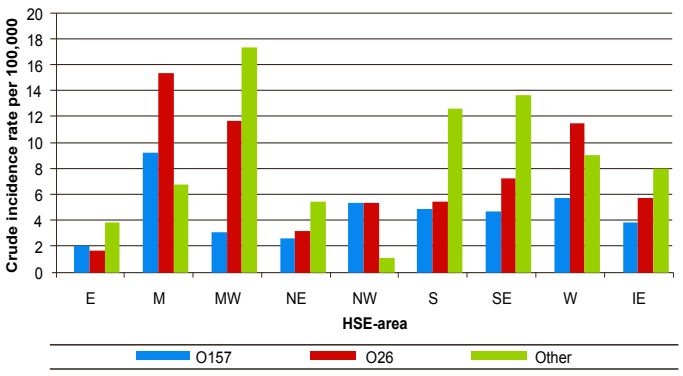

Figure 4: Crude incidence rate VTEC O157, O26 and other serogroups by HSE area, Ireland, 2016
For simplicity mixed infections were recorded as O157 if at least one strain was O157, as O26 if at least one strain was O26 but not O157, and as Other if only non-O157 or non-O26 strains were detected.

Table 4. Serotype and verotoxin (vt) profiles for strains associated with laboratory confirmed VTEC cases, as determined at the VTEC-NRL at PHL, Cherry Orchard Hospital, 2016

	Serogroup	VT1	VT1 + VT2	VT2	Not reported	Total
Culture positive notifications	O26	81	174	12	1	268
	O157	0	72	99	3	174
	O145	2	5	38	0	45
	O91	4	11	5	0	20
	O146	11	2	2	0	15
	O182	12	1	0	0	13
	O103	9	0	2	1	12
	O113	0	2	9	0	11
	O111	3	7	1	0	11
	O5	11	0	0	0	11
	Other*	48	25	37	7	117
PCR positive culture negative notifications		45	29	57	4	135

*Other includes Ungroupable strains

of diagnostic methods that detect a broader range of *E. coli* serogroups and the use of more sensitive molecular methods that detect verotoxin genes directly in stool samples[12] National guidance developed for the laboratory diagnosis of human VTEC in Ireland provides a co-ordinated approach to VTEC diagnosis in Ireland.[13]

Foodborne transmission was the first recognised transmission route for VTEC infection historically, with minced beef, unpasteurised dairy products, and fresh produce consumed raw all having been implicated in outbreaks across the world. Foodborne outbreaks typically comprise a small percentage of the total number of VTEC outbreaks in Ireland; this was also true for 2016, however, the general outbreak in 2016 associated with undercooked burgers underscored the importance of vigilance in relation to thorough cooking of burgers. The FSAI updated its advice to caterers in its Feb 2017 factsheet 'Advice for Caterers on Serving Burgers that are Safe to Eat'.[20] The advice emphasised that minced meat burgers should be fully cooked to ensure they are safe to eat and that 'caterers should not serve, offer or advertise undercooked or 'pink' burgers'.

Transmission by person-to-person spread, however, remained the most common transmission route reported in VTEC outbreaks and was involved in 56% of outbreaks. As usual, person-to-person spread was most frequently associated with private house and childcare facility outbreaks. Hand-washing and exclusion of cases in risk groups from high risk settings remains a key prevention measures for VTEC.[14]

In 2016, after person-to person spread, animal/ environmental contact was reported as the second most common route of transmission for VTEC outbreaks. This has long been recognised as a risk factor for VTEC infection [9-10] and cases due to this transmission route are not unexpected in Ireland given the large cattle population, the high proportion of rural dwellers, and the large number of farming families.[8] Advice is available on the HPSC website on how to minimise the risk of gastrointestinal infections following exposure to farm animals and environments, and for the safe recreational use of farmland.[16]

Contaminated drinking water was the third most commonly suspected mode of transmission. As in previous years, the outbreaks reported were linked with private water supplies. Exposure to water from contaminated untreated or poorly treated private water supplies has historically been recognised as a strong risk factor for VTEC infection in Ireland.[6-8, 15]This has been particularly pronounced following periods of heavy rainfall.

The focus for reducing the incidence of VTEC should be on reducing person-to-person and waterborne transmission. Efforts should focus initially on publicizing materials already developed in Ireland, including national guidance for crèche owners on the management of infectious-disease spread in CCFs [17], guidance for public health professionals on the

Table 5. Number of cases of VTEC (and percentage where information available) for selected risk factors, Ireland, 2016 (n=839)

Risk factor	Yes (% of known)	No	Unknown or not reported
Food suspected	44 (7.8%)	522	273
Exposure to farm animals or their faeces	289 (38%)	476	74
Exposure to private well water[a]	229 (44%)	523	87
Travel-associated[b]	30 (4.0%)	741	68
Attendance at a CCF[c]	140 (19%)	616	83
Attendance at a CCF[c] (among <5 yrs)	130 (45%)	159	22

[a]*Composite variable recoded from two different water supply exposure enhanced variables in CIDR*
[b]*Inferred from CIDR core variable Country of Infection*
[c] *CCF=childcare facility*

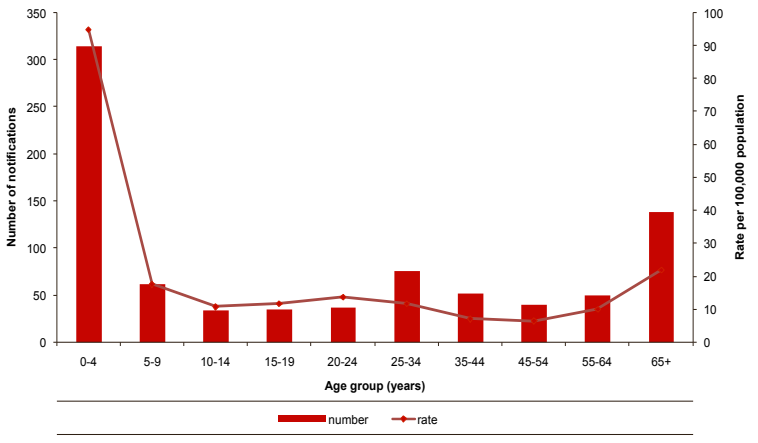

Figure 5. Number of notifications by age group, and age-specific VTEC incidence rates, Ireland 2016

management of VTEC cases and outbreaks in CCFs[14] and a leaflet developed for well owners outlining the infectious disease risks associated with drinking water from private wells, providing advice on actions that can be taken and what to do in the event the well water is contaminated.[18]

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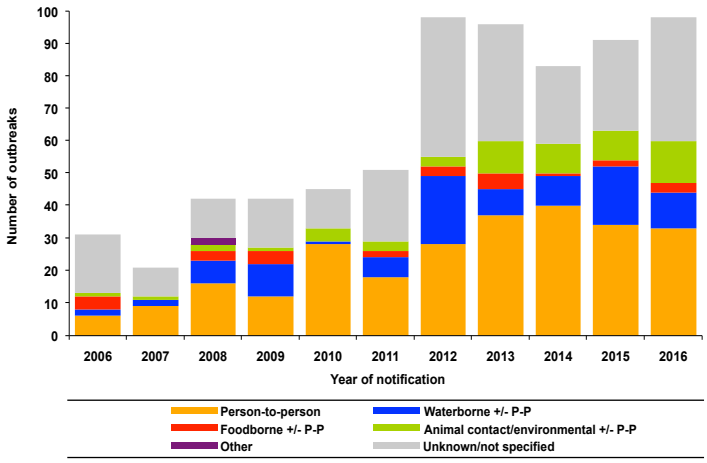

Figure 6. Number of VTEC outbreaks by suspected transmission route and year, Ireland, 2006-2016

Note: In this figure, reported transmission routes were grouped for simplicity. Any outbreak where food contributed was reported as foodborne, any outbreak where water contributed was reported as waterborne, any other outbreak where animal contact contributed was reported as animal contact. Person-to-person outbreaks include only those outbreaks reported as being due only to person-to-person transmission.

Table 6. VTEC outbreaks by suspected mode of transmission, Ireland, 2016

Transmission route	Number of outbreaks	Number ill	Number of associated CIDR events[a]
Person-to-person	33	84	80
Foodborne +/- person-to-person	3	16	31
Waterborne +/- person-to-person	11	24	29
Animal contact/Environment +/- person-to-person	13	22	26
Unknown/Not specified	38	80	84
Total	**98**	**226**	**250**

[a] *These figures may differ from the number ill, as asymptomatic cases identified as a result of screening will also be reported in CIDR*