Public Health England

Protecting and improving the nation's health

Outbreak Control Team Report: E.coli O157 outbreak linked to the consumption of raw cows' drinking milk from Barton Farm Dairy

About Public Health England

Public Health England exists to protect and improve the nation's health and wellbeing, and reduce health inequalities. It does this through world-class science, knowledge and intelligence, advocacy, partnerships and the delivery of specialist public health services. PHE is an operationally autonomous executive agency of the Department of Health.

Public Health England
Wellington House
133-155 Waterloo Road
London SE1 8UG
Tel: 020 7654 8000
www.gov.uk/phe
Twitter: @PHE_uk
Facebook: www.facebook.com/PublicHealthEngland

Prepared by: Public Health England on behalf of the Outbreak Control Team

Published July 2015
PHE publications gateway number: 2015170

Contents

1. Executive summary

An outbreak of *Escherichia coli* O157 (*E.coli* O157) including 7 primary and 2 secondary cases, was linked microbiologically and epidemiologically to the consumption of raw cows' drinking milk from Barton Farm Dairy in North Devon. One case was also infected with *Salmonella* Mbandaka which was an identical strain to one isolated from a raw cows' drinking milk sample taken from the bulk tank at the farm.

The outbreak was managed by a multiagency outbreak control team including the Food Standards Agency, Local Authorities, Animal and Plant Health Agency and Public Health England.

Five cases were identified from routine investigations. The additional cases were identified by whole genome sequencing and subsequently epidemiological links were made for the majority of these cases. An identical type of *E. coli* O157 was identified from animal faeces collected from the farmyard at the farm's premises.

Control measures included suspending the sale of raw cows' drinking milk from the farm, issuing a product recall information notice, providing details of bulk supplies to Local Authorities for follow up in their area. An action plan was agreed and implemented by the farm before they could recommence the sale of raw cows' drinking milk.

This outbreak demonstrates the value of using whole genome sequencing to ascertain the full extent of the outbreak.

2. Introduction

On 29 September 2014 Devon, Cornwall and Somerset (DCS) Public Health England Centre (PHEC) received a call from Wessex PHEC regarding a case of *E.coli* O157 in a child that routine questioning had identified as having consumed raw cows' drinking milk as the most likely risk exposure. The milk originated from Barton Farm Dairy, based in Barnstaple, North Devon. The farm sells bottled raw cows' drinking milk both locally and through online sales, delivered by courier, as well as cheese and other dairy products. Late the following day (30 September 2014) DCS PHEC received a call from West Midlands East PHEC (WME) regarding another case of *E.coli* O157 who was also thought to have consumed raw cows' drinking milk from Barton Farm Dairy, in this instance the milk had been provided as a free sample from a delivery van supplying other customers. There appeared to be no local cases of *E.coli* O157 linked to Barton Farm Dairy and no other links identified between the two cases.

An Outbreak Control Team (OCT) meeting was organised by DCS PHEC on 2 October 2014 with the key stakeholders to discuss immediate actions. Based on the available evidence, the principle control measure agreed at the OCT was for the Food Standards Agency (FSA) to advise the food business operator (FBO) at Barton Farm Dairy to suspend sales of raw cows' drinking milk and conduct a product recall. This action related to all sales of raw cows' drinking milk and any other products made with the unpasteurised milk, since September 2014, including cheese. FSA also published a recall information notice and advice for consumers on its website.

In total 4 primary cases were notified directly to the OCT, two by Wessex PHEC and two by West Midlands East. There was also one secondary case identified to the OCT. The other cases, who did not have obvious links to the farm and were subsequently identified and linked to the outbreak through microbiological testing (MLVA profiling and genome testing).

The objectives of the investigation were to prevent further cases occurring; both immediately and in the future. In order to do this, evidence was gathered to assess the possible association between consumption of the raw cows' drinking milk from Barton Farm Dairy and *E. coli* O157 infection. The action taken then focused on ensuring that all customers that had purchased the potentially affected unpasteurised milk or its products were advised not to consume it and

removing it from sale and distribution to other members of the public. Inspections, sampling and remedial actions were then taken forward at the farm before raw milk production could resume.

3. Background

E.coli O157 is the most common of the Vero cytotoxin-producing *Escherichia coli* (VTEC) responsible for human infection in the UK and the only serogroup of VTEC sought routinely by diagnostic laboratories in the UK. *E.coli* O157 and other VTEC infections cause a spectrum of illnesses, from mild non-bloody diarrhoea to haemorrhagic colitis. Haemolytic Uraemic Syndrome (HUS) complicates 2-7% of cases overall. According to the UK Subcommittee of the PHLS Advisory Committee on Gastrointestinal Infections (2000) the age specific incidence is highest in children under 5 years of age. The incubation period ranges from 6 hours to 10 days, averaging 2-4 days and this may differ depending on the number of organisms ingested. The infectious dose is low.

The natural reservoir of *E.coli* O157 is the gastrointestinal tract of animals, particularly cattle. Human infection can occur via contaminated foods, direct contact with infected animals or by secondary spread from cases, particularly in family groups with children under five years of age.

According to Byrne *et al* (2015) a total of 3717 cases of *E.coli* O157 were reported between 1 January 2009 and 31 December 2012 in England. They identified that incidence was highest in children aged 1-4 years, females had a higher incidence than males and white ethnic groups had a higher incidence than non-white ethnic groups. Progression to HUS was more frequent in females and children. Among VTEC O157 cases, Phage type (PT) 21/28, predominantly indigenously acquired, was also associated with more severe disease than other PTs.

An outbreak in the UK is generally defined as two or more cases from separate households linked to a common source. According to Pennington (2014) there have been other milk-borne outbreaks in the UK. However it is important to note that these were a result of pasteurisation failures, not due to the consumption of raw cows' drinking milk. Prior to this incident no outbreaks of human illness associated with raw drinking milk or raw cream have been reported in England and Wales since 2002.

The other outbreaks included:

- the Redhouse Dairy in West Lothian in May 1994 where over 100 people were infected. The dairy pasteurised, bottled and delivered milk to both domestic customers and retail outlets. *E.coli* O157 isolates with the same pulsed field gel electrophoresis (PFGE) type were found from 69 patients, the connection pipe from the pasteuriser to the bottling plant, rubber from one of the bottling machines, raw milk from a bulk carrier from a farm that supplied the dairy and bovine faeces from the farm
- an outbreak in North Cumbria affecting 114 people in February and March 1999. Milk from one farm was distributed to 321 premises including 11 commercial establishments. The outbreak was likely caused by the heat treated milk being contaminated with raw milk at the heat exchanger. Samples from calf pen straw bedding, the floors of pens and animal faecal samples had the same, or very similar PFGE types as the human outbreak isolates

From 1992-2000, the most common cause of milk-borne general outbreaks was *E.coli* O157, being the causative agent in nine outbreaks (*Campylobacter* spp. caused seven, *Salmonella* Typhimurium six). Five of these were linked to the consumption of raw milk.

The USA has seen an increase in outbreaks related to unpasteurised milk. Mungai, Barton Behravesh and Gould (2015) found that between 2007 and 2012 outbreaks related to unpasteurised milk increased. VTEC caused 13 of these and despite the health risks the demand for unpasteurised milk has increased.

4. Incident co-ordination

The OCT was led by DCS PHEC. Barton Farm Dairy is enforced by the FSA's Dairy Hygiene Inspectors (DHI) for food hygiene, and at the time of the outbreak Trading Standards, (labelling requirements), enforced by Devon County Council, also had a role. North Devon District Council were part of the OCT, however they only had responsibility for the cheese manufacture. Wessex and West Midlands East PHECs and Environmental Health teams from

Coventry and Eastleigh completed the local investigations in relation to the cases in their areas. PHE Food, Water and Environment (FW&E) Microbiology Laboratories at Porton Down and Birmingham completed microbiological testing on food samples that were taken and the PHE reference lab (Colindale) carried out further testing on the *E.coli* O157 isolates from the cases and other samples. The Field Epidemiology Service (FES) attended the OCT and further followed up cases to determine further potential sources of infection.

Due to the nature of the incident, the organism involved and the uncertainty regarding the extent of distribution and therefore number of cases that could be involved it was decided to risk assess the situation as IERP Level 2 under the PHE's Incident Reporting system (which is part of PHE's health protection database HPZone) and Information which means that the incident was 'Local with limited public health impact but greater than can be managed by one Public Health England centre'.

5. Outbreak investigation methods

The outbreak was investigated by the relevant enforcing authorities, as discussed along with the PHECs who managed the individual cases. Each organisation carried out their own investigations that were then fed back to the OCT. During the initial phase of the investigation all communications to Barton Farm Dairy were through the FSA's investigations team and the DHI. All sampling results were provided to the farm by the DHI.

5.1 FSA - The Dairy Hygiene Inspectors (DHI)

DHI conducted a full dairy hygiene inspection at Barton Farm Dairy on 2 October 2014 and carried out several follow-up inspections and visits. Samples of raw cow's drinking milk were taken from the bulk tank by DHI on 8 occasions from 21 October 2014 to 15 January 2015 and environmental swabs were taken on 6 October 2014. A timeline including the dates, details and outcomes of farm visits and sampling is included in Appendix 4.

As part of the response to this outbreak and investigations at two other farms potentially associated with cases of illness, all producers of raw cows' drinking milk in England and Wales were inspected and their milk tested during October 2014. The FSA developed an action plan to be achieved before sales of raw cows' drinking milk (for direct human consumption) could

recommence at premises associated with cases of illness and/or where pathogens were detected in samples of the raw milk during the wider sampling. The action plan required that:

- DHI should carry out at least one inspection during which they were content with the hygienic conditions at the premises
- Appropriate remedial action should be taken where necessary and that the Food Business Operator (FBO) should provide documented evidence of what they have done to address any issues and make it available to the Inspector
- DHI should then obtain satisfactory results for a range of relevant indicator organisms (ie plate counts at 30oC and coliforms) and pathogens (ie E. coli O157, Salmonella, Campylobacter and Listeria monocytogenes) in four samples of raw cows' milk on at least three separate occasions, each at least a week apart

The action plan indicated that once the FSA was content with the hygienic conditions at the premises and three satisfactory sets of sampling results were obtained, the sale of the raw cows' drinking milk could resume. The action plan was agreed with the OCT and Barton Farm Dairy agreed to the action plan during a visit on 7 November 2014.

The FSA notified Environmental Health teams within Local Authorities where bulk supplies were delivered so that they could be contacted directly to ensure milk was not further distributed. Further investigations have been conducted with the local authority for the distributor who was voluntarily delivering the raw drinking milk from the farm to customers who have purchased the milk via the internet or phone sales.

5.2 Public Health England

Wessex and WME PHECs completed the VTEC national questionnaire with the families of each case and identified the key risk factors that could have caused the illness.
The Gastrointestinal, Emerging and Zoonotic Infections department (GEZI) retrospectively examined the enhanced surveillance system for VTEC O157 and actively monitored the system for new cases reporting exposure either to raw milk or to Barton Farm Dairy.
The Field Epidemiology Service (FES) further interviewed cases to collect further information regarding potential exposures.

A review of the available microbiological and epidemiological evidence was carried out by the Gastrointestinal Bacterial Reference Unit (GBRU) and GEZI in order to identify any other cases

that may have been linked to this outbreak and to help inform the investigation. A total of eleven isolates from 2014 appeared to be linked by MLVA typing to the outbreak. Whole genome sequencing was carried out on these eleven isolates.

PHE laboratories examined and completed typing of food samples, human and animal isolates and environmental swabs that were forwarded to them from the DHI, EH teams and human isolates from the local hospital laboratories.
Putative isolates of VTEC O157 PT 21/28 were sent to GBRU for confirmation and typing. GBRU also examined MLVA results to identify isolates reported in 2014 that clustered with the outbreak strain.

5.3 Animal and Plant Health Agency

A visit to Barton Farm Dairy was undertaken on Wednesday 26th November by officers from the Animal and Plant Health Agency (APHA). The visit found nothing of serious concern. They were satisfied with the procedures being carried out at the farm with regards to animal health. A total of thirty animal samples were collected during this inspection and sent to Bury St Edmunds laboratory for analysis.

5.4 Environmental Health

The local Environmental Health Officers (EHOs) where the cases lived undertook investigations to determine the source of the milk, and how it was delivered to their customers. They obtained milk samples from both the case households, where possible, and from other customers who were identified when the distribution details were obtained.

5.5 Trading Standards

Devon and Somerset Trading standards Officers carried out investigations into the labelling and claims that were being made by the business, to assess whether the labelling complied with legal requirements and whether the claims being made on the packaging were false.

6. Results

6.1 Epidemiological

6.1.1 Public Health England

The epidemiological information of cases putatively linked to the outbreak by MLVA (n=11) were reviewed. However, only five of these cases (4 primary and 1 secondary) were initially known to be epidemiologically linked to Barton Farm Dairy.

Review of enhanced surveillance questionnaires – pre-sequencing

The enhanced surveillance questionnaires of the remaining cases were scrutinised and all isolates were sequenced. Following this exercise, none of the cases could be epidemiologically linked by exposure to Barton Farm Dairy (although one case reported consumption of RDM from another source) and with the exception of one DLV case, had not travelled to the South West of England where the farm is located.

Further epidemiological investigations – post sequencing

These cases were contacted again and asked specific questions about their consumption of dairy products and UK travel in the seven days before they became ill. The mother of two of the cases had stated that both children were fed a diet free from dairy or gluten. However, a review of the distribution details from the dairy revealed that the family had received a delivery of four litres of unpasteurised milk from Barton Farm Dairy. A further case revealed that they had received a free sample of milk from the RDM delivery service. This case was resident within the Anglia and Essex PHEC but worked in London where his exposure took place.

Descriptive Epidemiology

Of the nine primary and secondary cases, seven were male and two female. The median age was 5 years (Range1-49 years, Mean 11 years). The duration of symptoms ranged from two to seventeen days (Median six days). Two cases of HUS were reported. (Table 1). None of the cases had travelled outside the UK and none had travelled to the South West of England in the

seven days preceding their illness. Consumption of unpasteurised milk was reported by four of the cases (Table 2).

The epidemic curve indicates that contaminated food products were available for consumption over a period six weeks. This may in part reflect that families bought milk in bulk and stored it frozen. (Figure 1).

6.1.2 FSA Investigation

The inspections conducted by DHI at Barton Farm Dairy identified a number of non-compliances. This included one non-compliance regarding the lack of updating of medicine records and six non-compliances regarding hygiene issues. Action was taken by the farmer to address these issues. During a hygiene inspection carried out at Barton Farm Dairy on 16 March 2015 the conditions were considered to be satisfactory.

6.2 Microbiological

6.2.1 PHE - Clinical

A total of eleven isolates from 2014 appeared to be linked by MLVA to the outbreak. Six of these cases had identical profiles to the outbreak strain (VTEC PT 21/28). 11 samples were single locus variants (SLV) of the outbreak strain and three were double locus variants (DLVs).

6.2.2. PHE - Food And Water

Retail milk samples obtained by Eastleigh EHO's were examined. Eleven samples were analysed. One sample contained O157 and VT2 genes. However isolation of an *E.coli* O157 strain was not successful possibly due to the low numbers of bacteria present.

Milk samples (one frozen and one empty bottle) were received from Coventry EHOs and analysed. Both samples were culture and PCR negative for *E.coli* O157.
Bulk milk samples sampled by the DHI were sent to PHE Porton for testing. *Salmonella* isolates were identified in three separate bulk tanks. These were typed as an unnamed *Salmonella* and *Salmonella* Mbandaka.

6.2.3 FSA dairy hygiene investigation and microbiological results

The nine environmental swabs collected on 6 October 2014 were negative for *E. coli* O157.

Salmonella was detected in three raw cows' drinking milk samples collected on 6 October 2014 and in one raw cows' drinking milk sample collected on 25 November 2014.

The indicator organism *Listeria innocua* was detected at <10 cfu/g in four raw milk samples (one collected on 7 November 2014, one taken on 13 November 2014 and in two samples obtained on 25 November 2014).

Listeria monocytogenes was detected at <10cfu/g in two raw cows' drinking milk samples (one of which was collected on 25 November 2014 and the other on 7 January 2015). However, in order to determine whether the test results were compliant with the criteria set out in Regulation (EC) 2073/2005, information on the product shelf-life was required from the farm (ie in accordance with the regulation the levels of *L. monocytogenes* found in the milk could only be considered to have complied with the regulation if the milk's shelf-life was no longer than four days). This information, which indicated that the shelf-life of the product is four days, was first requested by FSA on 21 January 2015 and was requested again on several occasions but was only provided on 11 March 2015 following a query by local FSA officers concerned by the delay in receiving this information.

In accordance with the action plan, three satisfactory sets of raw cows' drinking milk samples were taken at Barton Farm Dairy on 30 December 2014, 7 January 2015 and 15 January 2015 (although it was only possible to determine that all three sets of samples complied with the regulatory requirements after the shelf life information was provided by the FBO on 11 March 2015).

6.3 Veterinary

E.coli O157 was identified in four of the 30 veterinary samples. The animal isolates were further examined at PHE Colindale. Three were determined to be vero cytotoxigenic *E. coli* O157 phage type 21/28 (VTEC O157 PT 21/28). This is the same phage type as the strain found in

the human cases. Molecular analysis using variable number tandem repeat (VNTR) showed that two of the animal isolates were indistinguishable from the human cases and one was a single locus variant. This is consistent with the farm animals being the source of the VTEC O157 infection in people.

7. Control measures

7.1 Overall co-ordination and management

The overall investigation was overseen by the OCT, led by the DCS PHEC. Meetings and minutes were co-ordinated by the DCS PHEC and the main method of communication within the OCT was by a group email.

7.2 Care of cases

All Cases were managed by their local PHEC. National guidelines for the management of these cases were followed and all public health actions undertaken including clearance samples to prevent further spread, as needed and providing advice and guidance.

7.3 Prevention of further cases

On 2 October 2014, the FSA suspended sales of raw cows' drinking milk at Barton Farm Dairy and issued a product recall information notice advising that Barton Farm Dairy was recalling its raw cows' drinking milk. Barton Farm Dairy was required to contact their customers and put information on their website and Facebook page. The FBO at Barton Farm Dairy put the necessary information about the suspension of RCDM sales and its recall on their social media but they did not manage to do the same on their website Although, there is no requirement for an FBO to contact customers buying goods directly the FBO at Barton Farm Dairy could have contacted their internet sales customers but they decided not to do so. The farm also suspended sale of the cheese made from the raw cows' milk.

The FSA put notifications of Barton Farm Dairy's recall on its website and messaged their followers in Twitter in order to inform the general public about the risk of consuming raw drinking milk from this particular farm.

Barton Farm Dairy was advised to rectify the labelling according to the labelling legislation to bear a minimum durability marking and ensure that any pre-packed raw cows' milk sold must be marked or labelled with the words: "This milk has not been heat-treated and may therefore contain organisms harmful to health". In addition, FSA provided advice on how the traceability record keeping could be improved to meet the requirements of the general food regulation.

The FSA also notified Environmental Health teams within Local Authorities where bulk supplies were delivered so that they could be contacted directly to ensure milk was not further distributed. Further investigations have been conducted with the local authority for a distributor who was voluntarily delivering the raw drinking milk from Barton Farm Dairy to customers who had purchased the milk via the internet or phone sales**.** The difficulty within this outbreak was that many customers purchased the milk in bulk and froze it. Therefore it was impossible to know whether further cases would arise when milk was defrosted and used.

As discussed in section 5.1, part of the response to this outbreak and investigations at two other farms potentially associated with cases of illness, all producers of raw drinking milk in England and Wales were inspected and their milk tested during October 2014. An action plan was developed that Barton Farm Dairy and other farms associated with cases of illness and/or where pathogens were detected had to complete before sales of raw cows' drinking milk could recommence.

7.4 Public Information

A product recall was issued by the FSA on 2 October 2014 (Appendix 1). On 3 October 2014 PHE and the FSA issued a joint Press Statement advising of the investigation into the two cases of *E. coli* O157 and the potential link to Barton Farm Dairy.
On 7th November 2014 the FSA published a message on its website to reiterate its advice that raw drinking milk should not be consumed by children and other vulnerable groups (Appendix 2).

7.5 Information to Barton Farm Dairy

The DHI visited Barton Farm Dairy at the start of the Outbreak, on 2 October 2014 and advised the farm to stop selling raw cows' drinking milk. North Devon District Council's Environmental Health also advised the farm to stop selling any products made using the raw cows' drinking milk, namely the cheese they manufacture. During the initial phase of the investigation all communications to Barton Farm Dairy were through the FSA's investigations team and the DHI. All sampling results were provided to the farm by the DHI.

A joint visit was carried out by DHI, Trading Standards and the DCS PHEC on 20 November 2014 to the farm to explain the on-going investigations. A further visit by the FSA DHI and Veterinary Field Leader on 16 December 2014 with the Barton Farm Dairy veterinarian present. Continuous communication with Barton Farm Dairy was maintained throughout the investigation via DHI.

7.6 Outline of enforcement action taken

7.6.1 FSA Dairy Hygiene Inspectors

The requirements of the action plan were achieved at Barton Farm Dairy following the receipt of satisfactory microbiological results for three sets of raw milk samples and the satisfactory hygiene inspection carried out on 16 March 2015. The farm was officially informed on 30 March 2015 that the restrictions on their sale of RCDM had been lifted, provided no further restrictions for other issues were in place. A TB notice from APHA was in force at the time. This was subsequently lifted on 16 March 2015. However, there were some issues with the TB status of some untested animals at the farm in question which were clarified by 16 April 2015.

7.6.2 Trading Standards

Devon and Somerset Trading standards are currently considering offences relating to consumer protection under the Unfair Trading Regulations for unauthorised use of logos.

7.7 Media responses

The recall notice issued by the FSA on 2 October 2014 resulted in seven articles on 3 and 4 October 2014 including the Western Daily Press, the North Devon Journal and ITV news.

Environmental Health News (EHN) online ran the story in their weekly round-up on 6 October 2014. There were follow up articles based on the recall notice from a variety of websites and blogs. Following the FSA's re-iteration of its advice that children and other vulnerable groups should not consume raw drinking milk on 7 November 2014, the Daily Mail published an article which referred to the outbreak associated with Barton Farm Dairy.

8. Discussion and conclusions

An outbreak of *E. coli* O157 including seven primary and two secondary cases, was linked microbiologically and epidemiologically to the consumption of raw drinking milk from Barton Farm Dairy. One case was also infected with *Salmonella* Mbandaka which was an identical strain to one isolated from a raw cows' drinking milk sample taken from the bulk tank at the farm.

The outbreak was managed by a multiagency outbreak control team including the FSA, Local Authorities, AHPA and PHE. Raw cows' drinking milk and raw milk cheese that had been placed on the market by Barton Farm Dairy was recalled on 2 October 2014. Sales of raw cows' drinking milk by Barton Farm Dairy were suspended by FSA on 2 October 2014 and the restrictions were officially lifted on 30 March 2015 following the receipt of satisfactory microbiological results for three sets of raw cows' drinking milk samples and a satisfactory hygiene inspection. There were no significant breaches in practice.

Four primary cases of *E. coli* O157 were initially reported to the local PHE Centre. Additional cases were identified by whole genome sequencing and subsequently epidemiological links were made for the majority of these cases. An identical type (PT21/28) was identified from animal faeces collected from the farmyard.

The outbreak strain - PT 21/28 is the most common PT overall found in cases from 2009-2012 in England, along with PT 8 with 1076 and 1069 cases respectively. PT 21/28 was found in a small number of travel related infections between 2009 – 2012 but was found to be the predominant PT amongst indigenous cases. (Byrne, *et al* 2015)

Low (2009) Found that in two separate studies in Scotland that phage type (PT) 21/28, producing VT2, was the most common type of E. coli O157:H7 isolated. On three-quarters

of farms with PT 21/28 present no other phage types were found. The majority of human cases in Scotland during each survey period were also PT 21/28. The proportion of human cases and cattle isolates that were PT 21/28 was much higher than any other phage type.

Outbreaks of *E. coli* O157 are not commonly associated with the consumption of raw drinking milk despite the recognised risk. In view of the potential seriousness of the disease, especially in the young and elderly, a comprehensive investigation and control of such an incident is essential.

The key to controlling the outbreak was the issue of a product recall information notice on 2 October 2014 and the ceasing of direct sales. Where bulk sales were made Local Authorities were made aware so that that onward sales could be stopped. Barton Farm Dairy was asked to inform their customers of the recall but it became evident that this was not successful. Information was put on Facebook by the farm but the web site was not used to make customers aware of the problem.

A rigorous investigation was made of procedures and practices on the farm, including animal management, milking and bottling. No breaches were found but a number of recommendations were made by the agencies. The FBOs cooperated with the investigation and made appropriate changes where recommendations were made.

Interpretation of MLVA and sequencing results

Microbiologically related strains of VTEC O157 are likely to originate from a common source. One measure of the degree of relatedness is determined by pairwise SNP distances. SNPs are single nucleotide polymorphisms and represent the difference between the case and reference genome; the greater the distance between SNPs, the greater the difference between the sequences.

Studies have shown that no pairs of epidemiologically related isolates are separated by more than 5 SNPs, with a mean of 1 SNP in isolates from same household or common source outbreaks. A SNP distance of 5 or less therefore provides good evidence that the isolates are closely related and can be attributed to a common exposure.

For MLVA, a threshold of a single locus variant or less provides the same sensitivity as if using WGS[1]. In other words, SLVs of a known outbreak strain can be considered part of an outbreak with confidence, even in the absence of an epidemiological link. However, double locus variants are considered to be part of an outbreak only if epidemiological links exist.

The maximum SNP distance in this outbreak was one meaning that the isolates from cases were closely related and well within the common source threshold for VTEC O157.
This outbreak of seven primary and two secondary cases of *E. coli* O157 was linked microbiologically and epidemiologically to the consumption of raw drinking milk.

It is likely that the level of contamination of the milk was low, given the results from samples of milk taken from the affected batch. A higher level of contamination could have resulted in a considerably larger outbreak.

This outbreak demonstrates the value of using whole genome sequencing to ascertain the full extent of the outbreak.

---

1 Whole Genome Sequencing for National Surveillance of Shiga Toxin Producing Escherichia coli O157.Dallman TJ, Byrne L, Ashton PM, Cowley LA, Perry NT, Adak G, Petrovska L, Ellis RJ, Elson R, Underwood A, Green J, Hanage WP, Jenkins C, Grant K, Wain J. Clin Infect Dis. 2015 Apr 17.

9. Tables & Figures

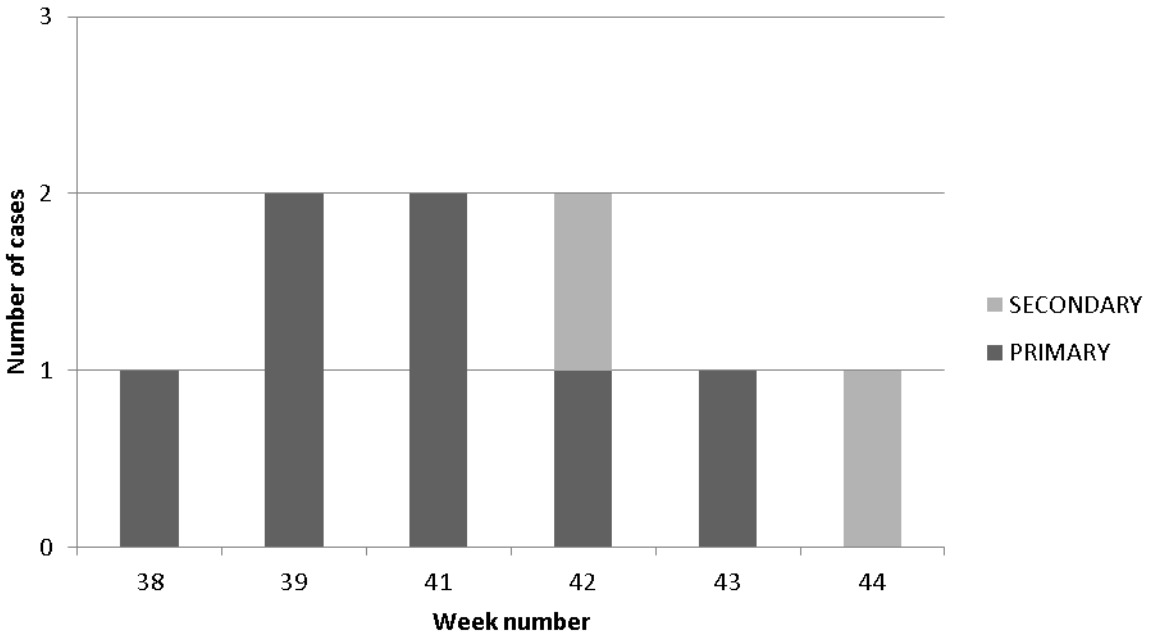
Table 1. Symptoms and health seeking behaviour reported by cases (n=9)

Symptom	**Number**	**%**
Diarrhoea	8	89
Blood in stools	7	78
Nausea	5	56
Vomiting	6	67
Abdominal pain	8	89
Fever	4	44
Healthcare		
GP	5	56
A&E	3	33
Admitted to hospital	7	78

Table 2. Selected risk factors reported by cases (n=9)

Selected risk factors	**Number**	**%**
Foreign travel	0	0
Travel in UK	1	11
Ate out	5	56
Handled raw beef	0	0
Ate beef	2	22
Drank pasteurised milk	4	44
Drank unpasteurised milk	4	44
Ate pre-packed salad	0	0
Handled raw vegetables	2	22
Ate raw fruit	2	22
Drank from private water supply	0	0
Any animal contact	3	33
Visited farm	1	11

Figure 1. Epidemic curve (Cases by week number n=9)



10. References

Byrne, L., Jenkins, C., Launders, N., Elson, R. and Adak, G.K. (2015) The Epidemiology, Microbiology and clinical impact of Shiga toxin-producing *Escherichia coli* in England, 2009-2012

Dallman, T.J., Byrne, L., Ashton, P.M., Cowley, L.A., Perry, N.T., Adak, G., Petrovska, L., Ellis, R.J., Elson, R., Underwood, A., Green, J., Hanage, W.P., Jenkins, C., Grant, K., Wain, J. (2015) Whole Genome Sequencing for National Surveillance of Shiga Toxin Producing Escherichia coli O157. *Clin Infect Dis*. Apr 17.

Hawker, J. et al. (2012) *Communicable Disease Control and Health Protection Handbook.* 3rd ed. Chichester: Wiley-Blackwell.

Jenkins, C., Grant, K., Wain, J. (2015) Whole Genome Sequencing for National Surveillance of Shiga Toxin Producing Escherichia coli O157. *Clin Infect Dis*. Apr 17.

Low, J.C (2009) The Epidemiology of *E.coli* O157:H7 in cattle and its control, with implications for human infections. *ACM/976 Advisory Committee on the Microbiological Safety of Food Information Paper, December.*

McAuslane, H., Morgan, D., Hird, C., Lighton, L. & McEvoy, M. (2014) Communicable Disease Outbreak Management Operational Guidance. *Public Health England,* Version 1.3.

Mungai, E.A.,Barton Behravesh, C. and Gould, H. (2015) Increased Outbreaks Associated with Nonpasteurized milk, United States, 2007-2012. *Emerging Infectious Disease Journal* (21) 1.

Pennington, T.H. (2014) *E.Coli* O157 outbreaks in the United Kingdom: past, present, and future. *Infection and Drug Resistance* (7) 211-222.

UK Subcommittee of the PHLS Advisory Committee on Gastrointestinal infection (2000) *Guidelines for the control of infection with Vero cytotoxin producing Escherichia coli (VTEC)* Communicable Disease and Public Health (3) 14-23.

11. Appendices

11.1 Product Recall by the Food Standards Agency

http://www.food.gov.uk/news-updates/news/2014/13120/barton-farm-recall

11.2 Information sent out by Food Standards Agency

http://www.food.gov.uk/news-updates/news/2014/13204/children-raw-drinking-milk

11.3 Press Releases relating to the Outbreak

Western Morning News, 3 October 2014

http://www.westernmorningnews.co.uk/North-Devon-Dairy-recalls-raw-milk-product-E-coli/story-23039977-detail/story.html

ITV News (Westcountry), 3 October

http://www.itv.com/news/westcountry/story/2014-10-03/e-coli-scare-at-north-devon-farm-dairy/

North Devon Journal, 4 October 2014

http://www.northdevonjournal.co.uk/North-Devon-farm-investigated-relation-E-coli/story-23043533-detail/story.html

EHN News, 8 October 2014

http://www.ehn-online.com/news/article.aspx?id=12800

Mail Online, 7 November 2014

http://www.dailymail.co.uk/health/article-2824557/Food-Standards-Agency-E-coli-warning-trendy-raw-milk-Five-children-taken-hospital-poisoning.html

11.4 Food Standards Agency timeline including sampling, farm visits and communications

RCDM samples	Date samples taken	Number samples and location	Tested for	Results important enough to highlight
	02/10/2014	2 samples taken from BULKTANK	*Campylobacter* sp *Salmonella* *E. coli* *Escherichia coli* O157 Total Viable Count, 3 days 30°C (MPCA)	Nothing to highlight
	06/10/2014	7 samples taken from BULKTANK on the same day than the environmental samples	Coliform bacteria Aerobic colony count at 30 Degrees C for 72h Coagulase Positive *Staphylococci* *Listeria monocytogenes* *Listeria* species *Salmonella* sp *Campylobacter* spp detection 25ml *Escherichia coli* O157	*Salmonella* was detected in 3 of the samples.
	07/11/2014	4 samples taken from BULKTANK	*Campylobacter* sp Coliforms *E. coli* *Escherichia coli* O157 *Listeria* sp *Listeria* sp. API *Listeria* Identification *Salmonella* sp Total Viable Count, 3 days 30°C (MPCA)	*Listeria innocua* <10 cfu/g was detected in 1 of the samples
	13/11/2014	3 samples taken from BULKTANK	*Campylobacter* sp Coliforms *E. coli* *Escherichia coli* O157 *Listeria* sp *Listeria* sp. API *Listeria* Identification	*Listeria innocua* <10 cfu/g was detected in 1 of the samples

			Salmonella sp Total Viable Count, 3 days 30°C (MPCA)	
	25/11/2014	4 samples taken from BULKTANK	*Campylobacter* sp Coliforms *E. coli* *Escherichia coli* O157 *Listeria* sp *Listeria* sp. API *Listeria* Identification *Salmonella* sp *Salmonella* confirmation Total Viable Count, 3 days 30°C (MPCA)	*Listeria innocua* <10 cfu/g was detected in 2 of the samples. *Listeria monocytogenes* <10 cfu/g was detected in 1 of the samples. *Salmonella* was detected in 1 of the samples.
	30/12/2014	4 samples taken from BULKTANK	*Campylobacter* sp Coliforms *E. coli* *Escherichia coli* O157 *Listeria* sp *Salmonella* sp Total Viable Count, 3 days 30°C (MPCA)	Nothing to highlight
	07/01/2015	4 samples taken from BULKTANK	*Campylobacter* sp Coliforms *E. coli* *Escherichia coli* O157 *Listeria* sp *Listeria* sp. (confirmed) API *Listeria* Identification *Salmonella* sp Total Viable Count, 3 days 30°C (MPCA)	*Listeria monocytogenes* <10 cfu/g was detected in 1 of the samples.
	15/01/2015	4 samples taken from BULKTANK	*Campylobacter* sp Coliforms *E. coli* *Escherichia coli* O157 *Listeria* sp *Salmonella* sp Total Viable Count, 3 days 30°C (MPCA)	Nothing to highlight

Environmental samples	**Date samples taken**	**Number samples and location**	**Tested for**	**Results**
	06/10/2014	9 swab samples: Tank Room Table, Tank Room Table 2, Transfer Pipe, Bulk Tank Ladder, Lid Tub, Cluster One, Cluster Two, Teat Cup Liner and Tank Room Sink	*Escherichia coli* O157	Not detected in any of the 9 swabs
Farm visits	**Date of visit**	**Who attended visit**	**Reason and discussions**	
	02/10/14	Dairy Hygiene Inspector (DHI)	Took two Raw Cows Drinking Milk (RCDM) samples, sent to ALS Trowbridge and also carried out a full dairy hygiene inspection. One non-compliance regarding the lack of medicine records and six non-compliances regarding hygiene issues. Documents relating to on-line sales/delivery/collection/SSC for September/RPA MQ25/ obtained	
	06/10/14	Dairy Hygiene Inspector (DHI) Lead Dairy hygiene Inspector (Lead DHI)	DHI and Lead DHI visited the farm. Lead DHI took RCDM samples and swabs. Spoke with the FBO and took details of their rounds man and various emails. Lead DHI took the samples to PHE Porton Down	
	08/10/14	Dairy Hygiene Inspector (DHI)	Went to the farm to gather delivery details, emails and ask about a possible shop that had been sent RCDM in Bideford.	
	09/10/14	Dairy Hygiene Inspector (DHI)	Carried out the follow up DH inspection from 02/10/14. Medicine records updated and hygiene issues resolved.	
	07/11/14	Lead Dairy hygiene Inspector (Lead DHI)	Lead DHI carried out inspection of farm… 'Discussed implementation of a HACCP based system for Raw Drinking Milk Provided template for product recall and FSA action plan., Discussed product dispatch monitoring and the FBO is purchasing a data logger. Discussed shelf life tests and consideration of *Listeria monocytogenes*. Provided advice on bottling and bottle lid security. 4x bulk tank samples collected and delivered to nominated laboratory ASL Trowbridge requesting pathogenic samples	
	13/11/14	Dairy Hygiene Inspector (DHI)	Collected three RCDM samples and sent them to ALS Trowbridge. Spoke with FBO	
	20/11/14	Dairy Hygiene Inspector (DHI) Lead Dairy hygiene Inspector (Lead DHI) Devon, Cornwall & Somerset PHE Devon & Somerset Trading Standards North Devon Environmental Health	Meeting at Barnstaple Civic centre with: Devon, Cornwall & Somerset PHE. Devon & Somerset Trading Standards. North Devon Environmental Health. FSA DHI and Lead DHI. After the meeting a site visit was held at the farm with the FBO	
	25/11/14	Dairy Hygiene Inspector (DHI)	Collected four RCDM samples and sent them to ALS Trowbridge. Spoke with FBO	
	16/12/14	Dairy Hygiene Inspector (DHI)	Meeting with FBO and Farm Veterinary Surgeon (from Torch Vets).	

		Field Veterinary Leader (FVL)	Talked through the last four results and the FBO shelf life test results. FBO showed and explained their new RCDM recording system. Advised on the "moving forward" protocol / action plan.
	30/12/14	Dairy Hygiene Inspector (DHI)	1st set of samples in agreed sampling/action plan collected
	07/01/15	Dairy Hygiene Inspector (DHI)	2nd set of samples in agreed sampling/action plan collected
	15/01/15	Dairy Hygiene Inspector (DHI)	3rd set of samples in agreed sampling/action plan collected
	16/03/15	Dairy Hygiene Inspector (DHI)	Final visit from DHI to assess farm and operation hygiene
Further communications	**Date of communication**	**Who contacted who**	**Reasons and discussions**
	03/10/14	Dairy Hygiene Inspector (DHI)	Spoke to the FBO on the telephone as he was very unhappy with the FSA statement, the television and media outside the farm. Contacted by Farm Community Network.
	03/12/14	Lead Dairy hygiene Inspector (Lead DHI)	e-mails sample results taken on 25/11/14 to Barton Farm Dairy with explanation
	17/12/14	Field Veterinary Leader (FVL)	Email FBO and Barton Farm Dairy's Veterinary Surgeon with minutes of meeting, action plan/action points, agreed sampling and clarification of some questions
	13/01/15	Field Veterinary Leader (FVL)	Email Barton Farm Dairy's FBO and Veterinary Surgeon with serotyping results for Salmonella, as requested during meeting.
	16/01/15	Dairy Hygiene Inspector (DHI)	DHI requested to contact FBO regarding shelf life testing in response to listeria identified in 2nd set of sample plan results
	23/01/15	Dairy Hygiene Inspector (DHI)	Advised by FBO of their intension to have a 4 day shelf life on RCDM product. DHI requested to confirm this with FBO in writing
	04/02/15	Field Veterinary Leader (FVL)	Telephone conversation with Barton Farm Dairy's solicitor to discuss progress and clarify requested actions by FSA. This was followed by email.
	08/02/15	Field Veterinary Leader (FVL)	Email to Solicitor with clear instructions of requirements for her clients (Barton Farm Dairy's FBO) in order to resume processing and sales of RCDM.
	12/02/15	Solicitor	Solicitor supplied FVL with information about shelf-life testing results, cleaning protocols and procedures. The shelf-life results were confusing as they indicated 5 days shelf-life (contrary to verbal communication of 4 days);the shelf-life samples did not include *Listeria monocytogenes* therefore, the results did not show the required information to satisfy Regulation (EU) 2073/2005.
	20/02/15	Lead Dairy hygiene Inspector (Lead DHI)	Emailed Barton Farm Dairy's solicitor with a letter explaining the requirements her clients need to comply with in order to resume production and sales of RCDM.
	24-25/02/15	Solicitor	Barton Farm Dairy's solicitor attempted to contact FVL. FVL replied by email that he won't be able to speak to her for a few days as he

			was attending courses/meetings and asked her to contact Lead DHI (phone call on 24/02/15 and email on 25/02/15)
	05/03/15	Field Veterinary Leader (FVL)	Email Barton Farm Dairy's solicitor to remind her that FSA is waiting for some clarification from her clients (ie Barton Farm Dairy) after letter sent by lead DHI on 20/02/15.
	05/03/15	Solicitor	Barton Farm Dairy's solicitor emailed FVL with some clarification on some of the questions asked but there were still some areas of no clarity (ie shelf life) on the processes carried out by Barton Farm Dairy's FBO.
	06/03/15	Field Veterinary Leader (FVL)	FVL emailed Barton Farm Dairy's solicitor to asked for further clarification on shelf-life
	11/03/15	Solicitor	Barton Farm Dairy's solicitor emailed FVL with clarification for RCDM shelf-life at Barton Farm Dairy and stated it is 4 days.
	26/03/15	Solicitor Field Veterinary Leader (FVL)	Barton Farm Dairy's solicitor emailed FVL to inform that Barton Farm Dairy has been put under TB restriction which might be lifted on 16/04/15 when they will resume RCDM production and sales. Replied from FVL to Barton Farm Dairy's solicitor on the matter.
	30/03/15	Operations Manager	Emailed official letter to Barton Farm Dairy's FBO and their solicitor confirming resume of RCDM production and sales at Barton Farm Dairy.