
Epidemiological investigation of the Central Scotland outbreak of *Escherichia coli* O157 infection, November to December 1996

J. M. COWDEN¹*, S. AHMED², M. DONAGHY³ AND A. RILEY⁴

¹ Scottish Centre for Infection and Environmental Health, Clifton House, Clifton Place, Glasgow G3 7LN

² Greater Glasgow Health Board (formerly CPHM Lanarkshire Health Board)

³ Scottish Executive Department of Health (formerly CPHM Lanarkshire Health Board)

⁴ Borders Health Board (formerly CPHM Forth Valley Health Board)

(Accepted 2 February 2001)

SUMMARY

On Friday, 22 November 1996, the microbiologist at a hospital in Lanarkshire, Scotland, identified presumptive *Escherichia coli* O157 in faecal specimens submitted by three patients with bloody diarrhoea, and confirmed its presence in one. Over the next 6 h, 12 more potential cases were identified. Investigations first indicated then confirmed a single food premises as the source of infection. Effective control measures were applied promptly. The outbreak was declared over on 20 January 1997, by which time 512 cases had been identified, and infection with the outbreak strain confirmed in 279. Twenty deaths occurred in cases during the outbreak and there were two more in cases during 1997. Seventeen of these deaths resulted from the outbreak. This paper describes the outbreak's epidemiological investigation, referring to other investigations, and control measures, where appropriate.

INTRODUCTION

In November and December 1996 an epidemiological investigation was carried out into a general community outbreak of food poisoning due to infection with *E. coli* O157. The objectives were to describe the outbreak, to identify the vehicles and source of infection and to effect rapid control. The initial investigation was completed within 8 h of the identification of the outbreak. The working hypothesis based on the initial investigation was that primary sporadic cases resulted from exposure to foods originating from, or contaminated by, foods produced at a single food premises. Control measures introduced on the basis of the working hypothesis were in place within 12 h of the identification of the outbreak, before the suspected food premises opened for

business the following day. These control measures were refined during the first week of the outbreak, but remained based on the working hypothesis, which was confirmed by the overall investigation. The overall investigation that followed the initial investigation consisted of a descriptive study of cases, three cohort studies, and a case-control study. The outbreak resulted in 512 cases, of whom 22 died, 17 as a result of the outbreak. Of the 279 confirmed cases, 272 were explained by the working hypothesis. The seven unexplained confirmed cases had no relevant common exposure. In two cohort studies strong associations were demonstrated between being a case and consuming sandwiches containing cold cooked meats either from the suspect food premises or premises supplied by them. There was no convincing evidence of other sources of infection. The number of new cases declined rapidly following prompt intervention.

* Author for correspondence.

MATERIALS AND METHODS

Descriptive epidemiology

Initial investigation

This commenced on the morning of Friday, 22 November 1996. After the microbiologist at the clinical diagnostic laboratory at the Law Hospital in Lanarkshire had identified the potential outbreak and gathered preliminary information, consultants in public health medicine (CsPHM) from Lanarkshire contacted other hospitals and general practitioners in the health board area. They identified a total of 15 potential cases, all but one of whom lived in or near Wishaw, a town of some 53 000 inhabitants in central Scotland.

Information was collected on nine of the potential cases by personal interview with them or their relatives using a standard form eliciting information on demography (age, sex and address), symptoms (including presence of diarrhoea and blood in stools) and exposure (including where food was bought and attendance at functions). This was collated with microbiological data.

The investigation was concluded by 18:00 h on Friday, 22 November 1996.

Overall investigation

The objectives were to document cases' age, gender, place of residence, symptoms and laboratory results, to establish if cases had been exposed to suspected vehicles of infection, and to identify cases unexplained by the working hypothesis.

The working hypothesis was that primary sporadic cases resulted from exposure to foods originating from, or contaminated by foods produced at a single food premises.

Case definitions evolved throughout the course of the outbreak. The final definitions are listed in Table 1 with sub-definitions in Table 2.

The outbreak strain was *Escherichia coli* O157 phage type (PT) 2, verocytotoxin (VT) type 2 positive; all isolates were subsequently shown to be indistinguishable by pulsed field gel electrophoresis (PFGE). All cases resident in Lanarkshire Health Board area (Lanarkshire) or Forth Valley Health Board area (Forth Valley) and cases resident elsewhere with any link to Lanarkshire or Forth Valley were considered to be part of the outbreak.

Deaths due to the outbreak were those occurring in

Table 1. Case definitions

Symptoms	Stool specimen positive*	Stool specimen negative†	
		Serology positive‡	Serology negative‡
Asymptomatic or no history	c	po	nc
Gastro-intestinal symptoms, but no bloody diarrhoea or thrombotic microangiopathy	c	po	nc
Bloody diarrhoea and or thrombotic micro-angiopathy	c	pr	po

c, confirmed; po, possible; pr, probable; nc, not a case.

* Positive for the outbreak strain either by primary culture or immunomagnetic separation.

† or not done.

‡ or post mortem evidence of infection with the outbreak strain.

cases where the fatal accident inquiry [1] deemed *E. coli* O157 infection to have caused or significantly contributed to death.

Case finding was effected by routine surveillance throughout Scotland, together with reports from hospital staff, environmental health officers, general practitioners and nursing home staff in Lanarkshire and Forth Valley.

Information was collected by personal interview with all potential cases, or their relatives, using structured questionnaires seeking demographic, clinical and exposure data. Many cases received multiple interviews.

Analytical epidemiology

Information was collected by personal interview with subjects, or their relatives, using structured questionnaires seeking demographic, clinical and exposure data relevant to the cohort.

Cohort study 1

On 17 November 1996 a lunch for elderly parishioners was held in a church hall in Wishaw. Guests and helpers constituted the cohort. The menu, guest list and names of helpers at this function were obtained from the organizers. The hypothesis tested was that cases were no more likely than non-cases to have consumed a particular food vehicle at the function.

Table 2. *Case sub-definitions*

Category of case	Characteristic
Sporadic Cohort	Not part of a specific group of people at risk Part of a specific group of people at risk: a member of food premises staff or a church lunch guest or helper or a pub party guest or organiser or a member of the nursing home staff or a nursing home resident
Primary	No documented contact in the 7 days before the onset of their illness with another symptomatic confirmed, probable, or possible case
Secondary	Documented contact in the 7 days before the onset of their illness with another symptomatic confirmed, probable, or possible case

Cohort study 2

On 23 November 1996 an 18th birthday party was held in a pub in Wishaw. The menu and guest list was obtained from the organizers. Guests and other customers of the pub that evening who could be traced constituted the cohort. The hypothesis tested was that cases were no more likely than non-cases to have consumed a particular food vehicle at the function.

Cohort study 3

Over the weekend 23–24 November 1996 various sandwiches were served to the residents and staff of a nursing home in Forth Valley. The list of foods offered and a list of staff were obtained from the manager. Staff on duty over that weekend constituted the cohort. The hypothesis tested was that cases were no more likely than non-cases to have consumed a particular food vehicle on 23 November 1996.

Case-control study

The case-control study commenced on 23 November 1996. Primary sporadic cases identified during the descriptive investigation were eligible for analysis. Cases nominated age and sex matched controls. The hypothesis tested was that consumption of foods purchased from a single food premises, or outlets known to be supplied by it, was associated with becoming a primary sporadic case. No chronological or numerical end point was set for the study, which terminated on 26 November 1996.

Microbiological investigations

The objectives of the investigations were to identify infection with the outbreak strain of *E. coli* O157 in potential cases, and contamination of suspect food vehicles and the environment.

One or more faecal specimens were obtained from 2427 potential cases. Isolates were confirmed and typed at Scottish National *Escherichia coli* Reference Laboratory. One or more serum samples were obtained from 440 potential cases.

A total of 1428 food and water specimens were cultured. In addition there were 167 environmental samples; 139 were obtained from the suspect food premises with the remainder coming from other retail outlets, and the food preparation area for the church lunch.

RESULTS

Descriptive epidemiology

Initial investigation

Of the 15 potential cases, 4 were confirmed, 3 were provisional, 6 probable, and 5 possible (Table 1). Nine of the ten confirmed or probable cases were interviewed.

Two cases had attended a church lunch on Sunday, 17 November 1996. Seven (of whom six lived in or near Wishaw) were apparently sporadic (Table 2), and had consumed cooked meats, sausage rolls or uncooked sausages from a single food premises, which had also supplied 'steak pie' to the church lunch.

The conclusion was that although there may have been sources of infection other than the suspect food premises, the evidence was sufficient to warrant immediate intervention and continuing investigation.

Overall investigation

The status of the 512 cases is presented in Table 3, their place of residence in Table 4, the date of onset of symptoms (where known) in Figure 1, and their age and gender in Figure 2.

It was concluded from the descriptive study that as the exposure of 272/279 (97.5%) of confirmed cases was compatible with the working hypothesis (Fig. 3) and as there was no convincing evidence of any other common exposure among these cases, or the seven cases who did not fit the working hypothesis, the suspect premises was entirely, or overwhelmingly the source of infection.

Table 3. Cases identified during the central Scotland outbreak of *E. coli* O157 infection

Symptoms	Stool specimen positive*	Stool specimen negative†	
		Serology positive‡	Serology negative‡
Asymptomatic or no history	35 (c)	53 (po)	nc
Gastro-intestinal symptoms, but no bloody diarrhoea or thrombotic microangiopathy	77 (c)	54 (po)	nc
Bloody diarrhoea and or thrombotic micro-angiopathy	167 (c)	58 (pr)	68 (po)

c, confirmed; po, possible; pr, probable; nc, not a case.

* Positive for the outbreak strain either by primary culture or immunomagnetic separation.

† or not done.

‡ or post mortem evidence of infection with the outbreak strain.

Table 4. Confirmed, probable and possible cases by health board

Cases	Lanarkshire	Forth Valley	Greater Glasgow	Lothian	Total
Confirmed	202	73	0	4	279
Probable	48	10	0	0	58
Possible	130	44	1	0	175
Total	380	127	1	4	512

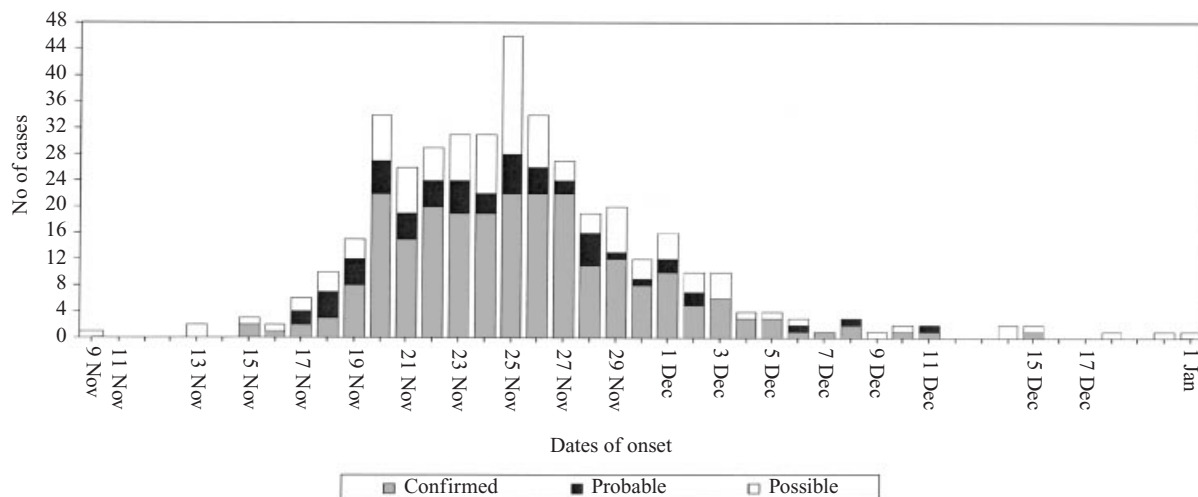


Fig. 1. Epidemic curve of 411 confirmed, probable, and possible symptomatic cases, with known dates of onset.

Analytical epidemiology

Cohort study 1

Data were obtained for all members of the cohort of 87 people. There were 45 cases of which 29 were confirmed. No statistical association was shown between being a case and the consumption of any

particular foodstuff. Eight cases died, a case fatality rate of 18%.

Cohort study 2

Data were obtained for all members of the cohort of 129 people. There were 25 cases of which 11 were

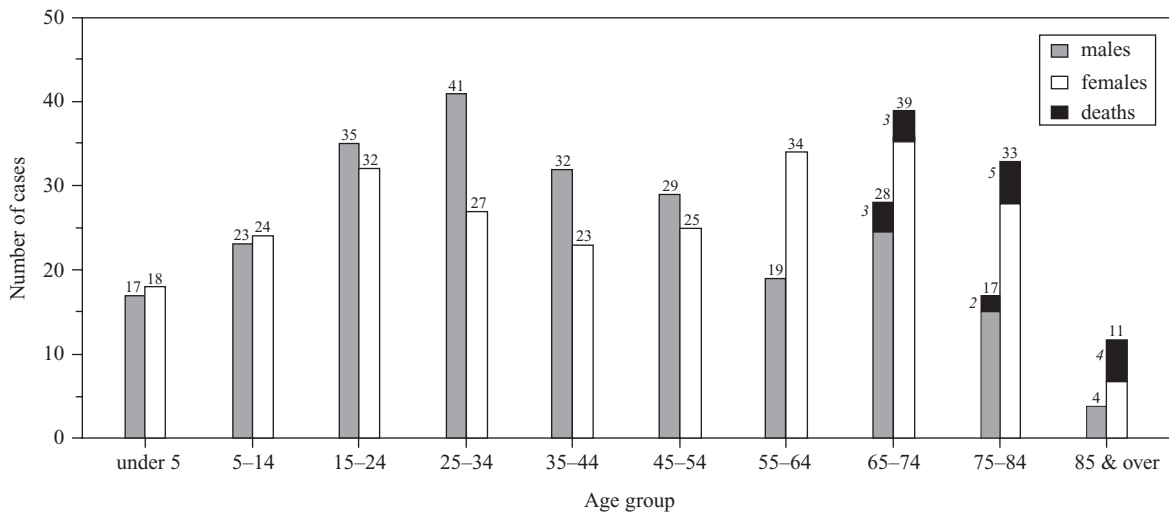


Fig. 2. Age and sex distribution of 279 confirmed cases, and 17 deaths due to the outbreak.

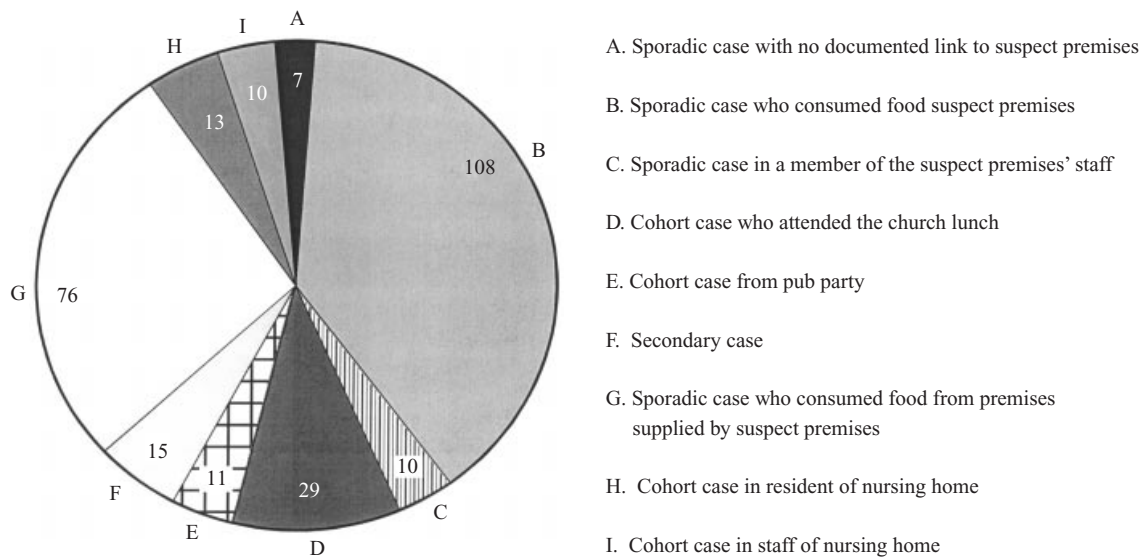


Fig. 3. Exposure of 279 confirmed cases.

Table 5. Food specific attack rates among the 18th birthday party cohort

Food	Ate food			Did not eat food			Relative risk	95% CI†
	Cases	Total	Attack rate (%)	Cases	Total	Attack rate (%)		
Cold meat*	19	64	30	4	57	7	4.3	1.53-11.70
Salad	6	22	27	16	102	16	1.7	0.77-3.94
Cakes	11	46	24	10	77	13	1.8	0.85-4.00
Sausage rolls	10	37	27	11	84	13	2.1	0.96-4.43
Quiche	5	17	29	17	107	16	1.8	0.79-4.36

* In sandwiches, bridge rolls or alone.

† Taylor series 95% CI for relative risk.

Table 6. Food specific attack rates among the residential home staff cohort

Food	Ate food			Did not eat food			Relative risk	95% CI†
	Cases	Total	Attack rate (%)	Cases	Total	Attack rate (%)		
Sandwiches*	6	7	86	4	30	13	6.4	2.46–16.81

* Most of which contained cold cooked meats.

† Taylor series 95% CI for relative risk.

confirmed. A statistical association was shown between being a case and consumption of cold cooked meats obtained from the suspect food premises (Table 5). There were no deaths.

Cohort study 3

Data were obtained for all members of the cohort of 37 people. There were 17 cases of which 10 were confirmed. A statistical association was shown between being a confirmed case and consumption of sandwiches, many of which were reported to contain cold cooked meats from an outlet supplied by the suspect food premises (Table 6). There were no deaths.

Case-control study

Controls were obtained for eight of the eligible cases. No controls had been exposed to the hypothesised risk. No statistical analysis was performed.

Microbiology investigations

Isolates from stool specimens from 279 cases were confirmed as the outbreak strain. In addition 159 probable and possible cases had serological evidence alone of recent infection with *E. coli* O157.

Two of the 139 samples from the suspect food premises were positive for the outbreak strain of *E. coli* O157. All 143 environmental samples from other premises were negative.

Twenty of the 1404 food specimens were positive for the outbreak strain of *E. coli* O157 namely:

- (i) nine from the suspect food premises (eight from raw meat and one from cooked ham);
- (ii) two from the households of private individuals (one from cooked ham from the public house

birthday party supplied by the suspect food premises, the other roast beef purchased from the suspect food premises);

- (iii) six from specimens supplied by the suspect food premises to other retail outlets (all roast beef);
- (iv) one from gravy decanted prior to its re-heating from the steak pie supplied by the suspect food premises and served at the church lunch;
- (v) two from premises supplied by the suspect food premises, but from foods not supplied by him (one from a specimen of corned beef and one from a specimen of roast pork).

DISCUSSION

We describe an epidemiological investigation that contributed to the rapid introduction of successful measures to control a large food-borne outbreak of *E. coli* O157 infection, and the identification of its cause, despite the absence of analytical epidemiological evidence linking most of the cases to the implicated food vehicles.

The epidemiological evidence upon which the control measures were based was largely descriptive. The limited analytical epidemiological evidence that became available later was only of value in supporting the microbiological and environmental evidence in confirming the working hypothesis in retrospect.

On 26 November 1996, we aborted a case-control study of cases who were not part of defined cohorts because the descriptive epidemiology had become so compelling that no possible outcome would have altered the outbreak's management. Had we failed to show an association between being a case and consuming food from the suspect food premises we would have rejected the result; demonstrating such an association would not have altered the outbreak's management. The critical question by that date was not whether the suspect food premises were a source of infection, but whether other sources existed as well.

This question could only be answered by a wide-ranging questionnaire covering all possible exposures, not a focused questionnaire addressing only one exposure.

The existence of seven primary sporadic confirmed cases with no demonstrable link to the suspect food premises tended to weaken the hypothesis, but their small number was reassuring. They may be explained in a number of ways. They may have been inaccurate historians, through forgetfulness or ignorance, or have been undocumented secondary cases: alternatively they may have been part of the background incidence of infection with this strain of *E. coli* O157. Because they shared no other biologically plausible common factor we inferred that there was no other common source of infection. As the numbers of cases contradicting the working hypothesis remained low, we believe the hypothesis stands.

We agree with the fatal accident inquiry that 17 deaths in cases were a result of the outbreak [1]. The inquiry considered 21 of the 22 deaths in cases. The death not considered by the FAI occurred 6 months after the outbreak was declared over. Another death occurred in a Lothian resident, considered to be a confirmed outbreak case during the outbreak on the basis of phage typing, verocytotoxin typing and links to Lanarkshire, but was subsequently excluded from outbreak on the basis of PFGE typing (Dr F.

Thomson-Carter, Scottish Reference Laboratory for *Escherichia coli* O157, personal communication, 2000).

ACKNOWLEDGEMENTS

The authors are grateful to all the members of the Outbreak Control Teams in Lanarkshire and Forth Valley Health Boards, especially Dr Fiona Thomson-Carter. They are also grateful to consultants in public health medicine who helped during the outbreak, and especially Dr Pauline Upton for her help in finalizing the data from Lothian. Mr Derek Roseborough and particularly Ms Beverley Wayne are also thanked for their help in managing the data for the graphs and tables, as well as Ms Wilma Ross, Mr Mark Getty and Mr Fernando Boero for preparing the graphs and tables.

REFERENCES

1. Cox G. Determination by Graham L. Cox, QC, Sheriff Principal of Sheriffdom of South Strathclyde Dumfries and Galloway into the *Esch. coli* O157 Fatal Accident Inquiry: Sheriffdom of South Strathclyde, Dumfries and Galloway, 1998.