Meat Grinders and Molecular Epidemiology: Two Supermarket Outbreaks of Escherichia coli O157:H7 Infection


Between 23 June and 15 July 1994, 21 cases (19 primary and 2 secondary) of Escherichia coli O157:H7 infection were identified in the Bethel, Connecticut, area. Three pulsed-field gel electrophoresis (PFGE) patterns from 15 isolates (I, n = 13; II, n = 2; and III, n = 1) were observed. A case-control study that excluded secondary cases and patients with PFGE II and III patterns (n = 16) demonstrated that consumption of food from one supermarket was associated with illness (15/16 cases vs. 31/47 geographically matched controls, odds ratio [OR] undefined, lower 95% confidence interval OR = 1.45, P = .018). No one food was associated with illness. Inspection of the supermarket revealed deficiencies in hygiene and meat handling practices. The 2 cases with PFGE II ate raw beef and raw lamb from a second supermarket. These outbreaks demonstrate the value of PFGE in supporting epidemiologic investigations and the potential for outbreaks arising from retail outlets.

Escherichia coli O157:H7 is an important cause of hemorrhagic colitis and the hemolytic uremic syndrome [1]. Most reported outbreaks are foodborne, and ground beef is the most frequently implicated source [2]. In Connecticut, laboratories have been required since 1990 to report E. coli O157:H7 isolates to the state Department of Public Health (DPH). As of November 1993, 32% of laboratories in Connecticut routinely screened for E. coli O157:H7 [3].

In June and July 1994, two simultaneous outbreaks of E. coli O157:H7 hemorrhagic colitis occurred that were related to two Connecticut retail supermarkets. We describe results of the epidemiologic investigation and discuss implications for food safety in retail stores.

Methods

Case definition. A case of E. coli O157:H7 infection was defined as the finding of E. coli O157 from stool or by IgG or IgM O157 lipopolysaccharide (LPS) seropositivity between 19 June and 25 July 1994 (study period) in a person who lived in or near Bethel, Connecticut.

Case finding. Initial cases were identified by a local laboratory. Surveillance was heightened within the Bethel area through telephonic interviews concerning exposures in the 7 days before onset of illness. From these, a questionnaire was developed.

Pulsed-field gel electrophoresis (PFGE) of E. coli O157:H7 isolates. All E. coli O157:H7 isolates obtained throughout Connecticut during the study period were subtyped by PFGE [4] at the Centers for Disease Control and Prevention.

Detection of O157 LPS antibody. Sera, where available, were tested for antibodies to E. coli O157 LPS by ELISA as previously described [5], except that alkaline phosphatase–labeled monoclonal antibodies against human IgG and IgM (Zymed Laboratories, San Francisco) were used as the detecting reagent. Seropositivity was defined as an IgG titer ≥1:80 or an IgM titer ≥1:320.

Case-control study. A telephone case-control study was conducted using 3 neighborhood age groups—matched controls for each patient obtained through a “street-organized” directory of residences and phone numbers. Controls were matched within each age-group: 2–4, 5–9, 10–14, 15–24, 25–44, 45–59, and ≥60 years. Each stratum of patient and 3 controls was asked about exposures in the 7 days before the onset of the patient’s illness. The questionnaire included exposures to a variety of supermarkets and fast food restaurants. Secondary cases, defined as a second case of E. coli O157:H7 infection within a household and occurring 2–5 days after an initial case, were excluded from the case-control study.

Environmental assessments. The local health department inspected all food establishments in the Bethel area shortly after the outbreak was identified but before analytic studies were done. The sources of water supplied to the patients were documented, and water quality data were assessed.

Statistical methods. Matched odds ratios (ORs) and exact 95% confidence intervals (CIs) were calculated using the procedure described by Thomas and Gart [6].
Figure 1. Dates of onset of diarrhea in 21 persons with E. coli O157:H7 infection near Bethel, Connecticut, 23 June to 15 July 1994. Pulsed field-gel electrophoresis (PFGE) patterns II and III refer to 3 isolates with different PFGE patterns.

Results

Case definition and case finding. Twelve cases were initially identified by the local laboratory. Heightened surveillance resulted in notification of 37 potential cases. Sera or stool were obtained from 17 persons, and 9 additional cases were identified. In total, 21 persons with E. coli O157 infection were identified during the outbreak period in an 11-km radius of Bethel.

Ten cases were confirmed by both stool culture and serologic testing. Five were confirmed by stool only (serology not done in 4); 5 additional cases were identified by serology only (stool culture not done in 1). Seven persons were both IgG and IgM antibody-positive. Five were positive for IgM and 3 for IgG alone. The epidemic curve suggested ongoing exposure, person-to-person transmission, or intermittent contamination of one or several products (figure 1). In 2 households, a secondary case developed 2 and 5 days after the primary cases.

The median age of the 14 female and 7 male subjects was 38 years (range, 2–86). Fifteen of the 21 cases were from Bethel (1990 census population 17,541), an overall attack rate of 0.9/1000 population. By age, specific attack rates per 1000 Bethel residents were 0.8 for 1–4 years, 1.1 for 5–14, 1.3 for 15–24, 0.3 for 25–34, 0.9 for 35–44, 1.0 for 45–54, 0.8 for 55–64, and 0.6 for ≥60.

Symptoms included diarrhea and abdominal cramps (each 95%), blood in stool (81%), nausea (76%), vomiting (33%), and fever (24%). Four patients required hospitalization for a mean of 3 days. There were no cases of hemolytic uremic syndrome and there were no deaths.

PFGE results. Of 16 E. coli O157 isolates, 15 were confirmed as O157:H7 and subtyped by PFGE. The first patient’s isolate was discarded before the outbreak was recognized. Three PFGE patterns were identified (figure 2). Eleven (10 primary cases) were indistinguishable (PFGE I). One differed by one band and was considered to be the same pattern. Two other strains (PFGE II) were indistinguishable from each other and different from the others. The pattern of 1 strain (from the last patient) was unique (PFGE III).

Four E. coli O157:H7 isolates obtained during the outbreak period from elsewhere in Connecticut were typed. One exhibited PFGE I, but the other patterns differed from those in Bethel.

Case-control study and case investigation. Case-control study data were collected for 19 primary case-patients and their controls. The case-control sets with PFGE II and III were excluded. Consumption of food purchased at one supermarket (supermarket A) in the 7 days before illness was statistically associated with illness (15/16 patients vs. 31/47 controls, OR undefined, lower 95% CI OR 1.45, \( P = .018 \)). The association remained when the analysis was confined to subjects exhibiting PFGE I (11/11 patients vs. 23/32 controls, OR undefined, lower 95% CI OR 1.03, \( P = .046 \)). Supermarket A was marginally associated with illness when all 19 case-control strata were included (OR = 9.1, 95% CI = 0.97–453, \( P = .055 \)).

Among those who ate food purchased from supermarket A, no one type of food was statistically associated with illness. Of 16 patients who consumed food from this supermarket, 7 ate ground meat (6/7 ground beef), 10 ate food from the delicatessen, and 14 ate ground meat or delicatessen food. Ten patients remembered 12 dates between 20 June and 4 July on which they had purchased ground meat or delicatessen products in the week before illness. One person with PFGE I, who did not report eating ground meat or delicatessen products, worked as a cashier in supermarket A and regularly handled meat products throughout the day.
Of the 3 patients excluded from the analyses, 2 (PFGE II) ate raw ground beef and lamb in an ethnic dish (kibbe) at a funeral meal 5 days before onset of their illnesses. There was no exposure other than the funeral meal in common between these 2 persons. The meats, purchased from a second supermarket (supermarket B), were ground from single high-quality cuts. No other cases of diarrhea were reported among funeral attendees, although no systematic survey of attendees was done. The remaining patient (PFGE III) ate very undercooked hamburger 5 days before illness; the ground beef came from a third supermarket. This patient had not shopped at supermarket A and did not attend the funeral.

Of 4 Connecticut E. coli O157:H7 isolates obtained during the outbreak period (but from outside Bethel area), 1 exhibited PFGE I (from a child with bloody diarrhea who lived 32 km outside Bethel). In the week before illness, the child had consumed food from supermarket A.

**Environmental assessments.** Inspection of supermarket A revealed several important deficiencies in hygiene and meat-handling practices: Knives and cutting benches were used for raw beef, chicken, and pork without washing and sanitizing between uses; each meat grinder was used for a range of beef, pork, turkey, and lamb products; and grinders were washed once a week with soap and water without disinfection. Meat product handling was not assessed in supermarket B.

No consistent water source was used by the cases; however, quality control indices of three major water supplies were uniformly good.

**Discussion**

PFGE of E. coli O157:H7 isolates was an essential tool in this investigation. When the 3 unrelated cases were excluded by PFGE, the association between illness and food eaten from supermarket A was strengthened. Exposure to food from the supermarket would not have been statistically associated with illness with all 19 case-control sets. In addition, PFGE enabled linkage of a child with E. coli O157:H7 infection who lived 32 km from Bethel to the larger outbreak. PFGE coupled with thorough epidemiologic investigation may be valuable in outbreaks where cases are from different geographic areas or where cases occur over a prolonged period.

Both outbreaks were associated with retail supermarkets. In the larger outbreak, contamination of multiple foods probably occurred after introduction of E. coli O157:H7 into the food preparation area. Cross-contamination to ground meats and food items, particularly delicatessen products, may have occurred over several days, which is supported by the epidemic curve, the shopping histories of patients, the failure to implicate a specific food item, and the environmental inspection. In addition, the isolate from the outlier case, which was indistinguishable from the PFGE pattern associated with supermarket A, was from a child who consumed food purchased from supermarket A. One person who did not eat meat products from supermarket A regularly handled meat and delicatessen products while working there and thus could have been exposed.

In the larger outbreak, the first case had no history of shopping at supermarket A. The isolate was not available for H antigen typing or PFGE subtyping. Thus, it is possible he was not part of the outbreak.

In the second outbreak, 2 persons at the same function ate raw beef and lamb prepared from single cuts of meat. This suggests the meats were contaminated before or during grinding.

The outbreaks are the second and third identified in Connecticut since E. coli O157:H7 surveillance began. These two outbreaks, like the previous one [3], would almost certainly not have been identified without laboratory-based surveillance and notification to DPH. DPH was notified of 1 case of E. coli O157:H7 between January 1993 and the date of the first case among Bethel residents. E. coli O157:H7 infection or hemolytic uremic syndrome are now legally notifiable in 33 of 50 states (August 1994, CDC unpublished data). The resource-intense nature of PFGE means that PFGE may not be an appropriate
tool in routine surveillance. However, PFGE was used after this outbreak to ensure no further cases were linked to either supermarket and illustrates that the technique can augment routine surveillance in some circumstances.

Little public health awareness or education has focused on the retail food industry. Another report documented a retail ground beef source for an outbreak of E. coli O157:H7 infection [7]. The association of outbreaks with retail supermarkets emphasizes the need for supermarkets to appropriately handle potentially contaminated products and equipment [8]. For example, it has been recommended that all meat grinding equipment be washed and sanitized every 4 h [8], rather than once a week (the practice in supermarket A). This outbreak illustrates the potential for cross-contamination of other foods, some of which may not be thoroughly or routinely cooked by the consumer.

In summary, 21 cases of E. coli O157:H7 in a small Connecticut town were documented over 23 days in June and July 1994. Two independent outbreaks were linked to two supermarkets through PFGE. PFGE enabled a geographically isolated case to be linked to the larger outbreak. These outbreaks demonstrate the importance of laboratory-based surveillance for E. coli O157:H7 infection. Prevention of such outbreaks requires further efforts to improve retail food handling and reduction of products contaminated with E. coli O157:H7 from entering retail outlets.

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References