Multistate Outbreak of *Listeria monocytogenes* Infection Linked to Delicatessen Turkey Meat


**Background.** Despite a decreasing incidence of listeriosis in the United States, molecular subtyping has increased the number of recognized outbreaks. In September 2000, the New York City Department of Health identified a cluster of infections caused by *Listeria monocytogenes* isolates with identical molecular subtypes by pulsed-field gel electrophoresis (PFGE) and ribotyping.

**Methods.** To determine the magnitude of the outbreak and identify risk factors for infection, we notified state health departments and conducted a case-control study. A case was defined as a patient or mother-infant pair infected with *Listeria monocytogenes* whose isolate yielded the outbreak PFGE pattern. Controls were patients infected with *Listeria monocytogenes* whose isolate yielded a different PFGE pattern. Patients were asked about food and drink consumed during the 30 days before the onset of illness.

**Results.** Between May and December 2000, there were 30 clinical isolates of *Listeria monocytogenes* with identical PFGE patterns identified in 11 US states. Cases of infection caused by these isolates were associated with 4 deaths and 3 miscarriages. A case-control study implicated sliced processed turkey from a delicatessen (Mantel-Haenszel odds ratio, 8.0; 95% confidence interval, 1.2–43.3). A traceback investigation identified a single processing plant as the likely source of the outbreak, and the company voluntarily recalled 16 million pounds of processed meat. The same plant had been identified in a *Listeria* contamination event that had occurred more than a decade previously.

**Conclusions.** Prevention of persistent *L. monocytogenes* contamination in food processing plants presents a critical challenge to food safety professionals.

*Listeria monocytogenes* was estimated to have caused 2500 infections and 500 deaths in the United States in 1997 [1]. Despite a decreasing incidence of listeriosis over the past 2 decades [2, 3], new tools, such as molecular subtyping, have increased the number of recognized outbreaks. Between 1980 and 2000, 15 foodborne outbreaks of listeriosis were published or reported to the Centers for Disease Control and Prevention (CDC); 10 of these outbreaks have occurred since 1998, and 3 of these involved multiple states (table 1). Centralization of processing and production of food, with its subsequent widespread distribution, increases the possibility of diffuse, widespread outbreaks of foodborne diseases, including listeriosis, when food is contaminated during the production process. Such outbreaks may not be recognized at the local level if there are only a few cases in any one jurisdiction and there is no routine integrated analysis of case-specific data among states. We report an outbreak that was detected using molecular subtyping tools, which allowed us to link cases occurring in many states [4].

**METHODS**

**Case finding.** In September 2000, epidemiologists from the New York City Department of Health and Mental Hygiene notified the CDC of a cluster of 9 patients who had been infected with *L. monocytogenes*...
over the previous 2 months. All isolates had the same ribotype and PFGE pattern. On 27 September, the New York City Department of Health and Mental Hygiene posted the outbreak PFGE pattern on the PulseNet listserv, which is maintained by the National Molecular Subtyping Network for Foodborne Disease Surveillance [5]. Soon thereafter, PulseNet assigned a pattern number, compared the pattern to the database, and identified isolates with indistinguishable PFGE patterns in New York, Michigan, and Georgia. On 2 October, the CDC posted a message on the PulseNet listserv that requested states to perform real-time PFGE typing on L. monocytogenes isolates and submit the patterns to the PulseNet National database. Epidemiologists from the CDC also contacted states and asked them to report epidemiologic information on their patients with L. monocytogenes.

**Case-control study.** To identify risk factors for infection, we conducted a case-control study. A case was defined as a patient or mother-infant pair from whom L. monocytogenes that matched the outbreak PFGE pattern was isolated from blood. Controls were patients with L. monocytogenes infection whose isolates had a different PFGE pattern. Controls were taken from the same states and same time period as were case patients. Patients were not matched with respect to age or sex. All patients were asked questions about food and drink they had consumed during the 30 days before they became ill. In the univariate analysis, ORs, exact 95% CIs, and 2-tailed Fisher exact P values were computed for the case-control study; P<.05 was considered significant. Variables that were significantly associated with disease in the univariate analysis were controlled in the stratified analysis; Mantel-Haenszel summary OR values and exact 95% CIs were computed. Means were compared using the Kruskal-Wallis test for nonparametric data, and the $\chi^2$ test for trend was used to examine dose response.

**Laboratory investigation.** Isolates of L. monocytogenes were characterized by automated EcoRI ribotyping, serotyping, and PFGE, as described elsewhere [6, 7]. All PFGE patterns were electronically sent to PulseNet for comparison with isolates from elsewhere in the United States.

**Traceback and environmental investigations.** The results of the case-control study were used to focus the product traceback investigation. To determine if patients could have obtained the implicated food product from a common source, officials from state health and agricultural departments visited retail establishments where patients reported purchasing the implicated product. Officials obtained names of products being sold at retailers at the time of each patient’s visit and during the 6 weeks before the onset of each patient’s illness. Production establishment identification codes were only available for products present in the retail establishment at the time of inspection. Product samples and environmental swab specimens were collected. Invoices from products sold at the time of exposure were submitted to the Food Safety and Inspection Service, US Department of Agriculture (USDA) for additional traceback to determine the site of production. Investigators from the Food

### Table 1. Outbreaks of foodborne Listeria monocytogenes infections in humans in the United States, 1980–2000.

<table>
<thead>
<tr>
<th>Year of outbreak; reference(s) or source</th>
<th>State(s)</th>
<th>No. of cases</th>
<th>No. of deaths</th>
<th>No. of miscarriages</th>
<th>Vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983; [25], CDC*</td>
<td>Massachusetts and Connecticut</td>
<td>62</td>
<td>14</td>
<td>9</td>
<td>Pasteurized milk</td>
</tr>
<tr>
<td>1985; [26]</td>
<td>California</td>
<td>86</td>
<td>8</td>
<td>21</td>
<td>Mexican-style cheese</td>
</tr>
<tr>
<td>1986; [27]</td>
<td>Pennsylvania</td>
<td>36</td>
<td>14</td>
<td>2</td>
<td>Unknown</td>
</tr>
<tr>
<td>1989; [28]</td>
<td>Connecticut</td>
<td>10</td>
<td>...</td>
<td>...</td>
<td>Shrimp</td>
</tr>
<tr>
<td>1994; [29]</td>
<td>Illinois, Michigan, and Wisconsin</td>
<td>69</td>
<td>0</td>
<td>0</td>
<td>Pasteurized chocolate milk</td>
</tr>
<tr>
<td>1998; [30, 31]</td>
<td>22 states</td>
<td>101</td>
<td>15</td>
<td>6</td>
<td>Processed meats</td>
</tr>
<tr>
<td>1998; [32]</td>
<td>Colorado</td>
<td>4</td>
<td>...</td>
<td>...</td>
<td>Hot dogs</td>
</tr>
<tr>
<td>1998; CDC*</td>
<td>Ohio</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>Unknown</td>
</tr>
<tr>
<td>1999; [32]</td>
<td>Florida</td>
<td>2</td>
<td>...</td>
<td>...</td>
<td>Delicatessen turkey, ham, and roast beef</td>
</tr>
<tr>
<td>1999; [32]</td>
<td>Connecticut, Maryland, and New York</td>
<td>11</td>
<td>...</td>
<td>...</td>
<td>Paté</td>
</tr>
<tr>
<td>1999; [32]</td>
<td>Minnesota</td>
<td>5</td>
<td>...</td>
<td>...</td>
<td>Delicatessen turkey</td>
</tr>
<tr>
<td>1999; [32]</td>
<td>New York</td>
<td>4</td>
<td>...</td>
<td>...</td>
<td>Hot dog</td>
</tr>
<tr>
<td>1999; [32]</td>
<td>New York</td>
<td>6</td>
<td>...</td>
<td>...</td>
<td>Unknown</td>
</tr>
<tr>
<td>2000; [33]</td>
<td>North Carolina</td>
<td>12</td>
<td>0</td>
<td>5</td>
<td>Homemade Mexican-style cheese</td>
</tr>
</tbody>
</table>

* Unpublished data, Centers for Disease Control and Prevention.
Safety and Inspection Service conducted an inspection of the implicated establishments.

RESULTS

Case finding. Thirty patients infected with an identical strain of *L. monocytogenes* were identified in 11 states (California, Connecticut, Georgia, Massachusetts, Michigan, New York, Ohio, Pennsylvania, Tennessee, Utah, and Wisconsin). Positive culture results were obtained from 17 May to 15 October 2000; there were 27 (90%) obtained after 15 July 2000 (figure 1). Eight cases were pregnant women or mother-infant pairs, and infection resulted in 2 miscarriages and 1 stillbirth. Twenty-two cases were men and nonpregnant women; the median patient age was 66 years (range, 29–92 years). These infections were associated with the deaths of 4 persons aged 67, 67, 77, and 78 years.

Case-control study. Interviews were completed with 18 cases and 24 controls. Characteristics of case patients and controls did not differ with respect to median age or sex. In a univariate analysis, 2 types of exposure were associated with illness: eating sliced, processed turkey meat from a delicatessen (for 13 of 17 cases vs. 5 of 24 controls; OR, 12.4; 95% CI, 2.3–72.5) and eating lettuce (for 17 of 18 cases vs. 13 of 23 controls; OR, 13.1; 95% CI, 1.4–600). Eating lettuce was not significantly associated with illness caused by the outbreak strain after controlling for turkey consumption; however, eating turkey remained significantly associated with illness after controlling for lettuce consumption (Mantel-Haenszel OR, 8.0; 95% CI, 1.2–43.3).

Laboratory investigation. All isolates had the same ribotype (DUP-1053) and serotype (1/2a) and were indistinguishable by PFGE using 2 enzymes (AscI PulseNet pattern GX6A16.0014 and ApaI PulseNet pattern GX6A12.0017) (figure 2).

Traceback and environmental investigation. Case patients reported obtaining delicatessen turkey meat from a variety of locations, but most did not recall the specific brand names of the turkey meat purchased. Information regarding place of purchase was available for 11 patients. Investigators collected 13 product samples and 17 environmental swab specimens from these locations. Eleven environmental swab specimens from 4 locations in New York City grew *L. monocytogenes*, and 6 of these isolates, which were from 3 delicatessens, were identical to the outbreak strain.

Establishment identification codes for turkey producers supplying the sites of purchase were available for products consumed by 9 patients from 5 states (1 patient from California, 2 from Georgia, 1 from Michigan, 4 from New York, and 1 from Tennessee). At the time of investigation, retailers identified by these 9 patients carried turkey meat produced at 27 different production establishments. One establishment, plant A, supplied delicatessen turkey meat to retailers identified by at least 6 patients and possibly 8 (based on brand name information). A second establishment, plant B, supplied delicatessen turkey meat to retailers identified by 5 patients. Combined, these 2 establishments could have provided the delicatessen turkey meat consumed by 8 of the 9 patients for whom traceback information was available.

Plant A is located in Arkansas, and plant B is located in Texas. Information provided by one of the parent companies identified a link between the 2 establishments. Plant B is a copacker for plant A. Turkey produced at plant B can leave the plant in 2 ways. First, it can leave as finished product; in this case, the turkey is identified as being produced at plant B.
Second, turkey produced at plant B can be sent to plant A, where it is processed further; in this case, the turkey is identified as being produced at plant A. Between May and October 2000, several turkey products were handled in this way.

On 8 December 2000, investigators from the Food Safety and Inspection Service began an investigation of the implicated establishments. A Food Safety and Inspection Service team conducted a food safety assessment of plant B from 8 December to 15 December. The Food Safety and Inspection Service collected and analyzed 11 environmental samples (including surfaces that the product contacted) and 17 product samples. All samples were negative for *L. monocytogenes*. However, on 14 December, on the basis of epidemiologic findings, plant B, which is located in Waco, Texas, voluntarily recalled 16 million pounds of processed turkey and chicken meat that were potentially contaminated with *L. monocytogenes*.

**DISCUSSION**

This outbreak involved 30 reported cases of listeriosis in 11 states, and additional cases may have gone undetected and unreported. Routine subtyping of *Listeria* isolates was critical to the identification of this diffuse, multistate outbreak that lingered for 8 months. This outbreak highlights the severity of listeriosis; infections resulted in 2 miscarriages, 1 stillbirth, and 4 deaths. The implicated food, delicatessen turkey meat, is known to be a high-risk food [8], and the traceback identified a single plant as the source of infection.

Delicatessen meats are a recognized source of *L. monocytogenes* and other foodborne pathogens. From testing performed between 1990 and 1999, the USDA found that an average of 5% of samples of ready-to-eat sliced ham and luncheon meats were contaminated with *L. monocytogenes* at production facilities [9]. In 2001–2002, there were 3 foodborne outbreaks specifically linked to ready-to-eat turkey meat: 1 in Denmark caused by multidrug-resistant *Salmonella* Typhimurium DT120 [10] and 2 in the United States caused by *L. monocytogenes* [11, 12]. In a formal risk analysis assessment of ready-to-eat foods performed in 2003 [13], processed meats were identified as the food that carried the highest risk for listeriosis.

In 1989, the USDA implemented a zero-tolerance policy for *Listeria* in ready-to-eat meats [14, 15]. The original impetus for this zero-tolerance policy was a clear link, established in 1989, between human listeriosis and a plant that produced turkey frankfurters [16, 17]. The isolates from 1989 and 2000 were indistinguishable from each other by routine PulseNet protocols and evaluation criteria, and plant B was the same plant implicated in the 1989 investigation.

These findings suggest that the outbreak strain may have persisted in plant B for at least 12 years and may have contaminated food intermittently. *Listeria* is a hardy organism that can survive on the floor, on or inside equipment, or in drains, and persistent environmental contamination of plants producing ready-to-eat products is likely common [18]. An event that leads to some environmental change, such as construction, may result in the contamination of the food product [19]. Prevention of persistent *Listeria* contamination in food processing plants presents a critical challenge to plant producers and food safety professionals.

Although it may be somewhat unconventional to use patients who have laboratory-confirmed infection with a nonoutbreak strain of *L. monocytogenes* as controls, doing so can be very effective in case-control studies of listeriosis outbreaks. Persons with listeriosis usually are not representative of the general population; they are likely to be pregnant women or elderly or immunocompromised persons. Therefore, finding appropriate controls is a challenge. The use of persons with *Listeria* infection as controls is a rapid, efficient means of identifying and interviewing a control group with similar levels of immunocompromise. Because the selection of diseased controls is likely to overmatch cases and controls and bias the results to the null (i.e., is less likely to identify a risk factor), a significant finding is all the more compelling.

Several characteristics of listeriosis, including the long incubation period (>1 month) and high mortality, make outbreaks difficult to investigate. In addition, in this outbreak the limited record-keeping of involved delicatessens required arduous effort by investigators to determine which plants most
likely produced the implicated products sold in each of the retail establishments.

This outbreak demonstrates the critical role of molecular subtyping in detecting outbreaks. Although such technology has been important for the detection of outbreaks of other pathogens [20–23], it is particularly critical for the investigation of *Listeria* outbreaks. Because *Listeria* leads to illness in only a small proportion of particularly susceptible persons among a large number who are exposed, infections are often scattered widely, despite a common source of exposure. In this context, seemingly unrelated or “sporadic” infections can be extremely difficult to differentiate from potentially outbreak-associated infections, a barrier that is compounded by the uniquely long incubation period for *Listeria*. As demonstrated here and elsewhere [24], use of molecular subtyping can improve detection of outbreaks of *L. monocytogenes* infection, and recognized outbreaks present important opportunities for public health professionals and regulators to take prompt action to prevent additional illness.

This outbreak highlights the challenge of detecting outbreaks in the era of centralized food production, and *Listeria* outbreaks are particularly challenging to identify and investigate because diffuse, low-level contamination can result in widely scattered and seemingly unrelated cases among high-risk persons over a wide geographic area and a long time frame. Routine PFGE typing of *Listeria* isolates combined with rigorous epidemiological analyses will likely result in increased detection of these outbreaks. Improved DNA fingerprinting technology and information-sharing are critical additions to the traditional armamentarium used by public health epidemiologists to respond to such threats in a changing environment.

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**References**


