LISTERIA MONOCYTGENES is a widely distributed environmental bacterium that can grow at refrigeration temperatures. Infection can cause severe illness and death. Persons at higher risk for infection include older adults, persons with weakened immune systems, and pregnant women and their newborns.

Listeriosis outbreaks have been associated with refrigerated ready-to-eat foods, including hot dogs, delicatessen meats, soft cheeses, milk, and other dairy products. For soft-ripened cheeses, the risk for listeriosis per serving is estimated to be 50- to 160-fold greater for cheese made from unpasteurized milk than pasteurized milk (1). Pasteurization kills L. monocytogenes; however, milk labeled as pasteurized and dairy products made from pasteurized milk can become contaminated due to inadequate hygiene practices after pasteurization. The earliest reported listeriosis outbreak in the United States in 1985, associated with Latin-style cheese (in particular, queso fresco and cotija), resulted in 142 illnesses, 28 deaths, and 20 fetal losses (2). Although the cheese was labeled as made from pasteurized milk, raw milk was inadvertently introduced into the pasteurized milk.

A US retail survey of several soft cheeses (Latin-style, blue-veined, mold-ripened) from 2000–2001 detected L. monocytogenes in 1.3% of cheeses made from unlabeled or unpasteurized milk and 0.5% of cheeses from pasteurized milk (3). However, pasteurized-milk cheese is much more commonly consumed than cheese made from unpasteurized milk. In a survey of food exposures conducted in 10 US states during 2006–2007, respondents reported eating types of soft cheeses (15.3% for blue-veined cheese, 6%–11% for other soft cheeses; pasteurization status unknown) more frequently than they reported eating cheeses made from unpasteurized milk in the previous 7 days (1.6%) (4). We describe outbreaks linked to soft cheese (both soft-ripened and acid-coagulated–ripened cheeses), demographic characteristics of the persons affected, and possible contributing factors to help inform prevention messaging for persons at higher risk.

The Study

Health departments in the United States electronically submit reports of foodborne disease outbreaks to the Foodborne Disease Outbreak Surveillance System (FDOSS). FDOSS captures information on etiology; implicated food; number of illnesses, hospitalizations, and deaths; and other features. We queried FDOSS for L. monocytogenes outbreaks (≥2 cases) in the United States from 1998, when pulsed-field gel electrophoresis was first used to investigate listeriosis outbreaks, through 2014. We obtained information on fetal losses; deaths; number of cheese types; pasteurization status of milk used to make the cheese; recall issuance; and isolate subtyping from published reports (5–11), unpublished data, and food recall announcements. We considered infections in pregnant women or infants ≤28 days of age to be pregnancy-associated. We considered outbreaks multistate if exposure to the implicated food occurred in ≥1 state.

Of 58 listeriosis outbreaks reported during 1998–2014, a total of 17 (30%) were associated with soft cheese (Figure), and resulted in 180 illnesses, 14 fetal losses, and 17 deaths (online Technical Appendix Table, https://wwwnc.cdc.gov/EID/article/24/6/17-1051-Techapp1.pdf). Most patients (146, 88%) were hospitalized. Of 116 patients for whom we had information on ethnicity, 38 (33%) were Hispanic. Of 140 cases with available data, 62 (44%) were pregnancy-associated. Median outbreak size was 8 cases (range 2–34 cases). Ten outbreaks were multistate, and 16 were associated with commercial products, of which 14 involved cheeses produced in the United States. The proportion of listeriosis outbreaks linked to soft cheese made from pasteurized milk (12 outbreaks, 33%) was significantly higher during 2007–2014 than during 1998–2006 (1 outbreak, 5%);
Listeriosis and Soft Cheeses, United States

p = 0.009). Clinical isolates from soft-cheese outbreaks predominantly fell in lineage I (14 outbreaks, 82%). We found 2 sequence type (ST) and clonal complex (CC) combinations in multiple outbreaks (ST5/CC5, 5 outbreaks; ST6/CC6, 2 outbreaks), whereas other ST and CC combinations appeared in single outbreaks (e.g., ST663 or ST558).

Latin-style cheeses were implicated in 11/17 (65%) outbreaks, accounting for 98 (54%) cases of listeriosis. The remaining outbreaks involved sheep’s-milk cheese, Middle Eastern–or Eastern European–style cheeses, Italian-style cheese, blue-veined cheese, and soft-ripened cheeses (1 outbreak each). Nearly all outbreaks (13/17) resulted in recalls.

FDA inspections of cheese-making facilities associated with outbreaks found sanitation and hygiene deficiencies (e.g., roof leaks over manufacturing equipment, an open sewer vent in a manufacturing room, and food-contact aprons stored in restrooms) (7–9); pest infestations (e.g., cockroaches, flying insects) (8); failure to hold food at proper temperature (8); and presence (8,11,12) or persistence of _L. monocytogenes_ in environmental niches of processing plants (9).

**Conclusions**

Consumption of contaminated soft cheese made under unsanitary conditions continues to be a common cause of listeriosis outbreaks in the United States. Multiple types of soft cheeses have been implicated in outbreaks, with most outbreaks linked to Latin-style soft cheese. These outbreaks disproportionately affect Hispanic pregnant women and their neonates, a group with 24 times higher risk for listeriosis than that of the general US population (13). The proportion of listeriosis outbreaks caused by consumption of soft cheese made from pasteurized milk has increased in recent years. Reasons for the increase may include the growing US Hispanic population (which increased from 11% in 1998 to 17% in 2014 [14]); a 2.5-fold increase in per capita consumption of cheese from 1980 to 2013 (15); consumer demand for certain types of cheeses; and an increase in the number of small producers, some of which had sanitary deficiencies. Better outbreak detection due to improved molecular subtyping and epidemiologic methods have resulted in a greater number of solved outbreaks; however, we did not observe a similar increased proportion of outbreaks linked to other foods during the same period. This finding suggests that changes in outbreak detection are unlikely to be the only contributor.

Despite the much higher risk for listeriosis per serving of cheese made from unpasteurized rather than pasteurized milk, during the study period, only about one quarter (4/17) of all outbreaks were linked to consumption of soft cheese made from unpasteurized milk. This result may be due, in part, to public health messages advising consumers at higher risk for listeriosis not to eat these cheeses.

For instances in which information was available, we noted environmental contamination and sanitation deficiencies in all outbreaks associated with cheese made from pasteurized milk. Although some of these deficiencies were unlikely to contaminate cheese directly, they indicate a lack of attention to sanitation and hygiene. This finding highlights the importance of robust sanitation and _L. monocytogenes_ monitoring programs for cheese manufacturers.

Consumers, particularly persons at high risk for listeriosis, are advised to avoid unpasteurized milk and dairy products made from unpasteurized milk. Soft cheeses made with pasteurized milk, including commercial cottage cheese, cream cheese, and processed mozzarella, are generally considered safe. However, some soft cheeses made with pasteurized milk, particularly Latin-style soft cheeses, have been produced in facilities with improper processing conditions, resulting in _L. monocytogenes_ contamination. Consumers cannot evaluate the conditions under which a cheese was made on the basis of labeling or other attributes of the product. We advise persons at higher risk for listeriosis (the elderly, persons with immunocompromising conditions, and pregnant women) to carefully consider whether to consume Latin-style and other soft cheeses implicated in previous outbreaks.
Acknowledgments
We thank state, local, and territorial health departments for reporting outbreaks to FDOSS, and the CDC Enteric Diseases Laboratory Branch, Division of Foodborne, Waterborne, and Environmental Diseases, National Center for Emerging and Zoonotic Infectious Diseases, for providing isolate subtype data.

About the Author
Ms. Jackson is an epidemiologist at the US Centers for Disease Control and Prevention. Her primary area of interest is infectious disease public health surveillance, with the objective of informing control measures.

References

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Listeriosis Outbreaks Associated with Soft Cheeses, United States, 1998–2014

Technical Appendix

### Technical Appendix Table
Characteristics of listeriosis outbreaks associated with soft cheese, United States, 1998–2014*

<table>
<thead>
<tr>
<th>Year</th>
<th>State</th>
<th>Implicated cheese†</th>
<th>No. infections</th>
<th>No. hospitalized</th>
<th>No. fetal losses</th>
<th>No. deaths</th>
<th>No. (%) pregnant Hispanic</th>
<th>No. (%) pregnant fetal losses</th>
<th>Made from pasteurized milk</th>
<th>Issues or observations</th>
<th>Serotype /Lineage / Sequence Type (ST) / Clonal Complex (CC)‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>North Carolina</td>
<td>Latin-style cheese</td>
<td>12</td>
<td>12</td>
<td>5</td>
<td>0</td>
<td>12/12 (100)</td>
<td>10/12 (83)</td>
<td>No</td>
<td>Made from contaminated unpasteurized milk (†)</td>
<td>4b / I / ST558 / CC type ST558</td>
</tr>
<tr>
<td>2003</td>
<td>Texas</td>
<td>Latin-style cheese</td>
<td>12</td>
<td>12</td>
<td>1</td>
<td></td>
<td>N/A§</td>
<td>No</td>
<td>Unknown</td>
<td>4b / I / ST1 / CC1</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>Texas</td>
<td>Latin-style cheese</td>
<td>12</td>
<td>12</td>
<td>0</td>
<td></td>
<td>No</td>
<td>No</td>
<td>Unknown</td>
<td>1/2b / I / Undetermined / Undetermined</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>Oregon</td>
<td>Sheep’s milk cheese</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0/2 (0)</td>
<td>0/2 (0)</td>
<td>Yes</td>
<td>Inadequate separation of processing rooms (2)</td>
<td>4b / I / ST4 / CC4</td>
</tr>
<tr>
<td>2008</td>
<td>Multistate</td>
<td>Latin-style cheese</td>
<td>8</td>
<td>8</td>
<td>2</td>
<td>0</td>
<td>8/8 (100)</td>
<td>7/8 (88)</td>
<td>Yes</td>
<td>Inadequate separation of processing rooms (2)</td>
<td>1/2a / II / ST1216 / CC11</td>
</tr>
<tr>
<td>2009</td>
<td>Multistate</td>
<td>Latin-style cheese</td>
<td>18</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>10/11 (91)</td>
<td>9/11 (82)</td>
<td>Yes</td>
<td>Unknown</td>
<td>4b / I / ST663 / CC type ST663</td>
</tr>
<tr>
<td>2009</td>
<td>Multistate</td>
<td>Latin-style cheese</td>
<td>8</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3/3 (100)</td>
<td>3/4 (75)</td>
<td>Yes</td>
<td>Sanitation deficiencies</td>
<td>1/2b / I / ST5 / CC5</td>
</tr>
</tbody>
</table>

* The outbreak associated with sheep’s milk cheese in 2006 included another case of listeriosis in the same state.

† Latin-style cheese

‡ ST: Sequence Type, CC: Clonal Complex

§ N/A: Not available

# Multiple reasons provided for outbreak investigation.
<table>
<thead>
<tr>
<th>Year</th>
<th>State</th>
<th>Implicated cheese†</th>
<th>No. infections</th>
<th>No. hospitalized</th>
<th>No. fetal losses</th>
<th>No. deaths</th>
<th>No. (%) Hispanic</th>
<th>No. (%) pregnancy associated</th>
<th>Recall</th>
<th>Made from pasteurized milk</th>
<th>Issues or observations</th>
<th>Serotype / Lineage / Sequence Type (ST) / Clonal Complex (CC)‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>Multistate</td>
<td>Latin-style cheese</td>
<td>6</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>6/6 (100%)</td>
<td>5/6 (83%)</td>
<td>Yes</td>
<td>Yes</td>
<td>Sanitation deficiencies Environmental contamination with <em>Listeria monocytogenes</em> Failure to ensure all employees conform to hygienic practices [4]‡</td>
<td>1/2b / I / ST5 / CC5</td>
</tr>
<tr>
<td>2010</td>
<td>Multistate</td>
<td>Middle Eastern, Eastern European, Mediterranean, and Latin-style cheeses</td>
<td>34</td>
<td>32</td>
<td>1</td>
<td>4</td>
<td>3/33 (9)</td>
<td>6/33 (18)</td>
<td>Yes</td>
<td>Yes</td>
<td>Environmental contamination with <em>Listeria monocytogenes</em> (5)</td>
<td>4b / I / ST6 / CC6</td>
</tr>
<tr>
<td>2011</td>
<td>Michigan</td>
<td>Middle Eastern-style cheese</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0/2 (0)</td>
<td>1/2 (50)</td>
<td>Yes</td>
<td>Yes</td>
<td>Environmental contamination with <em>Listeria monocytogenes</em> (5)</td>
<td>1/2b / I / ST5 / CC5</td>
</tr>
<tr>
<td>2011</td>
<td>New Jersey</td>
<td>Latin-style cheese</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1/1 (100%)</td>
<td>2/2 (100)</td>
<td>Yes</td>
<td>Yes</td>
<td>Environmental contamination with <em>Listeria monocytogenes</em></td>
<td>1/2b / I / ST5 / CC5</td>
</tr>
<tr>
<td>2011</td>
<td>Multistate</td>
<td>Blue-veined cheese</td>
<td>15</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0/14 (0)</td>
<td>0/15 (0)</td>
<td>Yes</td>
<td>No</td>
<td>Persistence of strains in environmental niches of processing plants in Italy (6)</td>
<td>4b / I / ST554 / CC554</td>
</tr>
<tr>
<td>2012</td>
<td>Multistate</td>
<td>Italian-style cheese (Ricotta salata)</td>
<td>22</td>
<td>21</td>
<td>1</td>
<td>4</td>
<td>1/14 (7)</td>
<td>9/22 (41)</td>
<td>Yes</td>
<td>Yes</td>
<td>Sanitation deficiencies (7)</td>
<td>1/2a / II / ST101 / CC101</td>
</tr>
<tr>
<td>2013</td>
<td>Multistate</td>
<td>French-style cheese (soft-ripened farmstead cheese)</td>
<td>6</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>1/6 (17)</td>
<td>1/6 (17)</td>
<td>Yes</td>
<td>Yes</td>
<td>Sanitation deficiencies</td>
<td>4b / I / ST6 / CC6</td>
</tr>
<tr>
<td>2013</td>
<td>Multistate</td>
<td>Latin-style cheese</td>
<td>8</td>
<td>7</td>
<td>0</td>
<td>1</td>
<td>5/5 (100%)</td>
<td>2/5 (40)</td>
<td>Yes</td>
<td>Yes</td>
<td>Environmental contamination with <em>Listeria monocytogenes</em> (5)</td>
<td>1/2b / I / ST5 / CC5</td>
</tr>
<tr>
<td>2013</td>
<td>Multistate</td>
<td>Latin-style cheese</td>
<td>9</td>
<td>8</td>
<td>2</td>
<td>1</td>
<td>9/9 (100%)</td>
<td>6/9 (67)</td>
<td>Yes</td>
<td>Yes</td>
<td>Environmental contamination with <em>Listeria monocytogenes</em> (5)</td>
<td>4b / I / ST2 / CC2</td>
</tr>
<tr>
<td>2014</td>
<td>Washington</td>
<td>Latin-style cheese</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>3/3 (100%)</td>
<td>1/3 (33)</td>
<td>Yes</td>
<td>Yes</td>
<td>Unknown</td>
<td>1/2a / II / Undetermined / Undetermined</td>
</tr>
<tr>
<td>Year</td>
<td>State</td>
<td>Implicated cheese†</td>
<td>No. infections</td>
<td>No. hospitalized</td>
<td>No. fatal losses</td>
<td>No. deaths</td>
<td>No. (%) Hispanic</td>
<td>No. (%) pregnancy associated</td>
<td>Made from pasteurized milk</td>
<td>Issues or observations</td>
<td>Serotype /Lineage / Sequence Type (ST) / Clonal Complex (CC)‡</td>
<td></td>
</tr>
<tr>
<td>------</td>
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<td>----------------------</td>
<td>--------------------------------</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>180</td>
<td>146</td>
<td>14</td>
<td>17</td>
<td>38/116 (33)</td>
<td>62/140 (44)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Information on fetal losses, ethnicity, and pregnancy status is not included in health department reports of foodborne disease outbreaks to the Foodborne Disease Outbreak Surveillance System (FDOSS) and therefore is missing for some outbreaks. In these instances, the denominator is the number of infections for which the characteristic was reported. CC, clonal complex; ST, sequence type.
†Latin-style cheese includes queso fresco, queso blanco, queso cotija, queso panela, queso requeson, queso ranchero, queso Oaxaca; Middle Eastern–style cheese includes Middle Eastern–style cheese, nabulsi, akawi; Eastern European–and Mediterranean–style cheese includes feta and Bulgarian feta. A complete list of cheeses recalled in these outbreaks is available at https://www.fda.gov/Safety/Recalls/default.htm. Summaries of CDC Listeria outbreak investigations are available at http://www.cdc.gov/listeria/outbreaks/index.html.
‡Outbreak isolates were subject to whole genome sequencing. We sequenced Nextera XT DNA libraries on the MiSeq platform (Illumina). After quality control of raw reads, we uploaded sequences with >20x coverage in the Listeria whole genome multilocus sequence typing database (wgMLST) in BioNumerics 7.5, and retrieved their sequence type (ST) and lineage. We identified clonal complex (CC) using information from the MLST database of the Institut Pasteur, France; in instances where no database matches existed, we labeled outbreaks Undermined (Texas 2005, Washington 2014). §Cheese was produced in a private home. ¶Cheese was produced at a manufacturing facility in Mexico and brought across the border for personal use. #L. monocytogenes isolates from these 2 outbreaks were indistinguishable by pulsed-field gel electrophoresis. The Food and Drug Administration sought a permanent injunction against the manufacturer after the first outbreak. The owners moved the manufacturing facility to a nearby location and reopened under a new name.

References


