Lessons Learned from the Canadian Listeriosis Outbreak

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Objectives

- Review the microbiology of Listeria and listeriosis
- Discuss control of listeria in the environment
- Review lessons learned and future challenges
- Discuss recent large Canadian outbreak

Federal food safety responsibilities are shared

Production
Processing/Distribution/Retail/Food Service
Consumers

On-farm Food Safety Programs
Policy and Standards
Surveillance/Early Warning

Education and Outreach
Enforcement
Public Health Surveillance

Primary Responsibilities

AAFC
HC
CFIA
PHAC

Why listeriosis remains an issue?

Widespread in environment, hardy
Psychrotrophic
High case-fatality rate

Background: Listeriosis

- Listeriosis is a rare, but severe foodborne illness
  - Cases per million* of listeriosis each year
  - 2.2 hospitalizations per million population
  - Case-fatality rate is high
- High-risk populations include:
  - Pregnant woman/fetuses/neonates
  - Elderly persons
  - Immunocompromised individuals
- Many foods associated with illness
Canadian Outbreaks of Listeriosis

- Cabbage (1981)
  - Coleslaw was vehicle, but contaminated with manure: serotype 4b
- Imitation crab meat (2000): serotype 1/2b
- Whipping cream (2001): flat whipping cream positive for Lm- serotype 1/2a
- Cheese-ripening solution (2002)
  - Lm - serotype 4b isolated from reconstituted Penicillium / Brevibacteria ripening solution
- Cheese (2002)
  - Filter and UV-treated well-water suspected source of Lm serotype 4b
- Heat-treated & firm cheese (2002): serotype 1/2a
- Cheese outbreak (2008): serotype 1/2a
- Deli-meat (2008): serotype 1/2a

Economic impact of listeriosis

- Thorn Apple Valley (Jan, 1999) – 35 million pounds of ready-to-eat deli meat
- Bil Mar Foods (Feb, 1999) – 33.1 million pounds of hot dogs
- Wampler (Oct, 2002) – 27.4 million pounds of ready-to-eat turkey and chicken
- Maple Leaf (2008) – 1.38 million Kg from Eastern Canada; 390,000 kg from Western Canada

Listeriosis Surveillance

- 1990-1999 - Listeriosis (all types) national notifiable disease (NND)
- 2000 - Listeriosis removed from NND
- 2001 - Listeriosis Reference Service created
- Listeriosis remained reportable in all P/T, except QC (added in 2004)
- 2006 - Invasive listeriosis added to NND
- 2009 - Listeriosis officially reinstated as a nationally notifiable diseases
- 2010 Listeria monocytogenes added to NESP organism list

Challenges of Listeriosis: Implications on Surveillance

- Majority of cases are sporadic
  - further complicated when geographically dispersed
  - definite link to outbreak not always possible
  - what is true rate of unreported illness due to non-invasive strains?
- Long incubation period
  - can be up to 70 days
  - traceback and/or source attribution difficult or impossible to do
- Listeriosis
  - mainly high-risk populations
  - elderly may be predisposed (versus younger population)
  - food behaviours and consumption patterns not well known in higher risk groups

Why listeriosis remains an issue?
Top Ten Improper Food Handling Practices = foodservice establishment outbreaks!!!

% Foodborne Illness Outbreaks

1. Improper cooling 30%
2. Advance preparation 25%
3. Infected person 17%
4. Inadequate reheating for hot holding 13%
5. Improper hot holding 12%
6. Contaminated raw food or ingredient 11%
7. Unsafe source 9%
8. Use of leftovers 8%
9. Cross-contamination 3%
10. Inadequate cooking 3%

Source: www.foodsafe.ca

Top 10 Factors Contributing to US Foodborne Illness 1998-2002

- Food at room temperatures for several hours – 29%
- Hand (i.e., no glove) contact by food handler – 25%
- Inadequate cleaning of equipment – 22%
- Handling by infected person or carrier – 20%
- Inadequate cold-holding temperature – 19%
- Cross contamination from raw animal products – 19%
- Insufficient cooking – 19%
- Raw ingredients contaminated by animal or environment – 19%
- Slow cooling – 19%
- Inadequate holding time or wrong temperature – 19%

Source: CDC 2006 MMWR 55:1-34

Consumer Exposure to Listeria during Food Consumption

- Amounts and frequency of consumption of a food
- Frequency and levels of L. monocytogenes in ready-to-eat food
- Potential to support growth of L. monocytogenes in food during refrigerated storage
- Refrigerated storage temperature
- Duration of refrigerated storage before consumption
- All related directly or indirectly to the immune status of the individual

Barriers and Challenges to the Control of Listeria

- The microorganism is commonly found in the environment, including food processing, distribution, retail environments, and in the home
- Because L. monocytogenes is everywhere it can easily enter processing plants via raw foods, humans, equipment, vehicles, shoes, etc.
- Once inside a processing plant, L. monocytogenes can establish itself and persist for long periods of time
- It can grow in many foods during refrigerated storage

How does Listeria get into Foods?

- The environment (1.3-7.3%)
- Ruminant farms (5.9-33%)
- Raw foods
- Food processing environments (<0.1 to > 30%)
- Ready-to-eat foods (0.17-4.7%)
Examples of persistence in food operations

<table>
<thead>
<tr>
<th>Food</th>
<th>Time</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheese</td>
<td>4 years</td>
<td>Switzerland</td>
</tr>
<tr>
<td>Cheese, blue veined</td>
<td>7 years</td>
<td>Sweden</td>
</tr>
<tr>
<td>Ice cream</td>
<td>7 years</td>
<td>Finland</td>
</tr>
<tr>
<td>Smoked mussels</td>
<td>3 years</td>
<td>New Zealand</td>
</tr>
<tr>
<td>Cold smoked salmon</td>
<td>4 years</td>
<td>Denmark</td>
</tr>
<tr>
<td>Pâté</td>
<td>2 years</td>
<td>UK</td>
</tr>
<tr>
<td>Jellied pork tongue &amp; rillettes</td>
<td>8 years</td>
<td>France</td>
</tr>
<tr>
<td>Cooked poultry</td>
<td>1 year</td>
<td>Ireland</td>
</tr>
<tr>
<td>Cooked poultry</td>
<td>12 years</td>
<td>USA</td>
</tr>
</tbody>
</table>

Investigations have revealed...

- More than one strain of *Listeria monocytogenes* can exist in a food processing environment...family sticks together!
- Certain strains persist for months or years...they don’t want to leave!
- Not always obvious how they arrive either...dust (construction, etc.), manure, ...even good ol’ butter...

Testing for *Listeria*: W5...

Contact versus non-contact surfaces...

Non-food contact surfaces include...

- Drains and aerosols
- Standing water
- Cracks in floors and walls
- Smokehouses
- Floors in heavily-trafficked areas
- Tires on fork-lift trucks
- Food and wheel baths that are not in “good shape”
- High-pressure hoses
- Cleaning tools (mops, squeegees, brushes, etc.)
- Trash cans

Non-food contact surfaces include...

- Under-side of conveyor belts
- Hollow rollers
- Roller guards, bearings, etc.
- Chili tanks
- Refrigerators, cold rooms
- Ice makers
- Overhead pipes
- Drip pans
- Wet insulation
- Maintenance tools, dust from construction, air filtration

Where is the greatest risk?

- Environmental, equipment or people...the greatest risk is after the lethality step (i.e., just before and during packaging)
Food contact surfaces include...
- Chill brines
- Containers
- Racks for transportation
- Conveyor belts
- Slicers, dicers, shredders, blenders, etc.
- Table and equipment used to assemble/package product
- Packaging equipment
- Hand tools, gloves, aprons, etc.
- Metal surfaces with gaps (bad welding, etc.)
- Food residue sites and other hard to clean areas

When to sample?
- Before the start of food production
- During production of food commodities
- At end of production line (end-product testing)

...always keep in mind...
...if Listeria is there...we'll find it!

Things to think about...
- Environmental sampling is more sensitive for assessing control than end-product testing
- Testing finished product offers no clue as to how contamination occurred...but it does tell you that you have a problem...
- Environmental sampling provides useful information needed to help avoid end-product contamination
- Testing for Listeria species can be more conservative (i.e., not looking for pathogen), but may lead to greater assurance of controlling L. monocytogenes (i.e., academia vs. industry?)

Testing: the Who of W5?
- Knowledge of aseptic technique, microbiology and issues therein...do not just "go through the motions"
- Experience in environmental sampling very important
- Experience and familiarity with plant equipment
- Familiarity with production and flow inside plant environment

Testing: the what of W5?
- Indicator organisms (i.e., Listeria-like)
- Indicators like Listeria species
- The pathogen itself (Listeria monocytogenes)

Considerations:
- indicators may be better and safer
- indicators occur more frequently than the pathogen
- faster turnaround times for indicator tests versus pathogen-specific assays

Test and/or monitor for Listeria?
- Regulations...always good to comply
- Recalls can ruin business...bad press lingers
- Consumer demands
- Warning system in place to reduce (and avoid) problems
- Helps to verify HACCP and SOPs for plant production
Usefulness of end-product testing?
...aka...addressing the WHY?

- You found *Listeria* on a contact (or non-contact) surface
- Compliance with regulations
- Verification of monitoring program(s)

Remember...
- *Listeria* is NOT uniformly spread
- Lot should be held until negative result for representative sample being tested
- Do you have a corrective action plan should product be *Listeria* positive?

What we knew by 1992...

- Some plant layouts were unacceptable...
  - Including problems associated with older plants
- *Listeria* will continue to enter plant environments
- *Listeria* on floors increases risk of positive packaging lines
- Importance of harborage sites in equipment
- Air, people, packaging materials, etc. are rarely sources of *L. monocytogenes*
- Contamination is typically limited to one line

What we knew by 1992...

- Rinsing equipment during production is detrimental to *Listeria* control
- It is much easier to maintain control than to regain control
- Must continually strive for zero positive!
- *Listeria* CAN be controlled in RTE operations

Q: Do you have a transient or resident problem?

Transient
- removed by cleaning and sanitizing
- limited amount of food is exposed

Resident
- become established in one or more sites, multiply and persist over time (e.g., months, years)
- numerous lots of food can be exposed

Two conditions can lead to contamination of multiple lots of food by resident strains

Biofilms...what a mess!

- Microorganisms are embedded in a matrix of organic polymers produced by the cells...perfect protection...
- Biofilms provide favorable conditions for growth and survival (e.g., resistance to disinfectants)
Biofilms...what a mess!

- Biofilms and niches are of greatest concern when located after a kill step (e.g., cooking)
- The processing environment typically appears clean and acceptable
- Microbial sampling is necessary to detect a biofilm or niche
- Lm can attach and form biofilms on a variety of surfaces (stainless steel, polymers, rubber gaskets)

Examples of niches

- Inside hollow rollers for conveyors
- Hydraulic oils and bearing greases
- Inside hollow supports for equipment
- Between two layers of material

Non-foodgrade lubricants reduced the amount of L. monocytogenes better (p<0.05) than food-grade lubricants, but use of food-grade lubricants is required in food contact areas.

VTT Technical Research Centre of Finland (2007).

How to sample?

- Swabs
- Sponges
- Mop strings
- Sweepings from floor
- Product fines
- Residue on filters
- Anything appropriate to the situation

Where to sample?

- Sites should be selected based on experience
- Final step in the process before exposed product packaged
- Zone concept
  - Zone 4: Locker rooms, cafeteria, hallways
  - Zone 3: Telephones, forklifts, walls, drains
  - Zone 2: Non-product contact surfaces in close proximity to product: Exterior of equipment, refrigeration units, floors
  - Zone 1: Product contact surfaces: Conveyors, tables, racks, vats, tanks, utensils, filling and packaging machines

Two different approaches to monitoring production facility

- Sampling product as it is processed
- Sampling the environment

Can we get some control here?
Strategies for control

1. Eliminate biofilms and niches that can lead to unacceptable microbial contamination.

2. Use a sampling program that can assess in a timely manner whether the environment is under control.
   Goal: to detect a problem, if one exists

Practical highlights for Listeria control:

- Research versus real-life...

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Optimal</th>
<th>Can survive (but not grow)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (ºC)</td>
<td>-1.5 to 3</td>
<td>45</td>
<td>30 to 37</td>
<td>-18</td>
</tr>
<tr>
<td>pH</td>
<td>4.2 to 4.3</td>
<td>9.4 to 9.5</td>
<td>7.0</td>
<td>3.3 to 4.2</td>
</tr>
<tr>
<td>Water activity</td>
<td>0.96 to 0.95</td>
<td>&lt;0.99</td>
<td>0.97</td>
<td>&lt;0.90</td>
</tr>
<tr>
<td>Salt (%)</td>
<td>&lt;0.5</td>
<td>12 to 16</td>
<td>N/A</td>
<td>≥20</td>
</tr>
</tbody>
</table>

pH 5 to 5.5 and water activity <0.95
pH <5 and any water activity
water activity ≤0.92 at any pH

Commodity dependent!

What is Lm control anyways?

- Having in place proper steps/procedures to destroy Lm (pasteurization/cooking) – listeriocidal is preferred ☑
- Being able to identify sources of contamination – being the detective, always assume everything is contaminated ☑
- Having in place a procedure to eliminate and/or reduce contamination sources – ideally want pre-processing and post-processing control since Lm is a smart bug and will find a way to get in and stay in ☑

Franco’s Thoughts

- High pressure hoses for drains?
- Compressed air for equipment?
- Wet mid-shift cleaning?
- Stacking?

Cleaning tools

- Mixing’n’matching tools?
- Daily sanitation of tools?
- Storage
- ‘re-usable’ cloths/sponges?

...I found Listeria...now what?

- Rotation of sanitizers?
- Sanitizer biology (contact time, [ ], Tº, etc.)
- Listeria “hot spot”? What is the “norm”??
Franco’s Thoughts

Reducing the Risk of Listeriosis

- Avoiding cross-contamination (sanitation)
- Incorporating ingredients that inhibit the growth of Listeria (e.g., lactate and diacetate)
- Processes that inhibit growth during shelf life, e.g., low moisture, high acidity, freezing
- Ingredients that can inactivate listeriae (e.g., nisin, growth inhibitor packaging, dipping products)
- Processes that can inactivate listeriae (e.g., cooking, steam heat or hot water)

Trend Analysis: Helping Process Control

Swanson, 2009

Changes to HC’s Listeria Policy - Managing Risks

HC is currently reviewing its policy on “Listeria monocytogenes in Ready-to-Eat (RTE) Foods”:
- Applies to all high-risk RTE foods (i.e., dairy, produce, fish and seafood, meats), in both federally-registered and non-registered sectors

Specific policy changes include:
- Updated operational and sampling guidelines to enhance the ability to detect L. monocytogenes
- Potential for new end-product compliance criteria consistent with Codex
Proposed HC Criteria

New end-product compliance criteria have been developed to be in-line with the International Codex Alimentarius standards:

<table>
<thead>
<tr>
<th>Categories</th>
<th>Action level for Lm</th>
<th>Nature of concern</th>
<th>Level of priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) RTE foods in which growth of Lm can occur until the end of shelf life</td>
<td>Detected in 125 g (5 x 25g)</td>
<td>Health Risk 1</td>
<td>High</td>
</tr>
<tr>
<td>2A) RTE foods in which a limited potential for growth of Lm to levels not greater than 100 CFU/g can occur until the end of shelf life</td>
<td>&gt;100 CFU/g</td>
<td>Health Risk 2</td>
<td>Medium -Low</td>
</tr>
<tr>
<td>2B) RTE foods in which growth of Lm cannot occur until the end of shelf life</td>
<td></td>
<td></td>
<td>Low</td>
</tr>
</tbody>
</table>

Wide variety of food matrices lead to different challenges

Summer 2008 Canadian listeriosis outbreak

Foodborne Listeriosis Outbreaks in Canada

Common Listeria Serotypes in Canada

<table>
<thead>
<tr>
<th>Serotype</th>
<th>Blood (%)</th>
<th>CSF and brain tissue (%)</th>
<th>Specimens associated with pregnancy and miscarriage (%)</th>
<th>Stools (%)</th>
<th>Total by serotype (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2a</td>
<td>253 (45.8)</td>
<td>45 (52.3)</td>
<td>1 (12.5)</td>
<td>6 (21.4)</td>
<td>48</td>
</tr>
<tr>
<td>1/2b</td>
<td>82 (14.9)</td>
<td>11 (12.8)</td>
<td>0</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>1/2c</td>
<td>5 (0.9)</td>
<td>1 (1.2)</td>
<td>1 (12.5)</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>4b</td>
<td>160 (10.0)</td>
<td>22 (25.6)</td>
<td>6 (75)</td>
<td>22 (76.0)</td>
<td>32</td>
</tr>
<tr>
<td>Others</td>
<td>52 (9)</td>
<td>7 (8.1)</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>552</td>
<td>86</td>
<td>8</td>
<td>28</td>
<td>-</td>
</tr>
</tbody>
</table>

Clark et al., 2009
In 2008, a national outbreak of foodborne listeriosis resulted in 57 confirmed cases in 7 provinces, with a total of 23 deaths.

**2008 Listeriosis Outbreak - Key Facts**

- The 2008 listeriosis outbreak was identified following three weeks of higher than expected case reports of listeriosis in Ontario.
- On August 6, 2008, the Toronto Public Health Unit informed CFIA of two listeriosis cases at a Toronto nursing home.
- Following a food safety investigation led by CFIA, the source of the *Listeria* was linked to Establishment 97B (Maple Leaf Foods Canada) RTE meat products.
- Eventually seven provinces were implicated in the outbreak.

**Canadian Listeriosis Outbreak**

**Case Exposures to RTE Meat Products**

| Number of confirmed cases with likely exposure to Maple Leaf Food deli meat products during their exposure period | No. of confirmed cases |
|---|---|---|
| Ate/likely ate deli meat (n=X) | Yes | No | Unknown/No Info |
| Ate/likely ate deli meat supplied by MLF (n=X) | 50 | 4 | 3 |

* Public health inspectors were able to verify product information for 27 of the 50 cases who consumed deli meat. Public health inspectors verified that the institutions where these 27 cases consumed deli meat had served deli meat produced by Maple Leaf Establishment 97B. Among the remaining 23 cases who reported eating deli meat, 9 cases reported eating Maple Leaf brand products, but it was not verified whether or not these products originated from Maple Leaf Establishment 97B.

**Geographic Distribution**

<table>
<thead>
<tr>
<th>Province</th>
<th>Confirmed</th>
<th>Deaths</th>
<th>Probable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alberta</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>British Columbia</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Manitoba</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>New Brunswick</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Ontario</td>
<td>41</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>Quebec</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Saskatchewan</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>57</td>
<td>20</td>
<td>2</td>
</tr>
</tbody>
</table>

* PFGE results were not available for 2 cases.

**Descriptive Epidemiology**

- Mean age: 75
- Median age: 78
- Age range: 29-98
- Female: 67%
- Immunocompromised*: 100%
- Institutional exposure**: 84%

* Prior health status was known for 31 of the 57 cases and all 31 cases had underlying conditions.
** Residents, inpatients or outpatients of institutions in the 70 days prior to their illness.
Public Health Actions

- August 17, 2008 – Recall → CFIA and ML Foods warned the public not to serve or consume Sure Slice Road Beef and Corned Beef, because these products may be contaminated with Lm
- August 19, 2008 – Recall → CFIA and ML Foods warned the public not to serve or consume any RTE deli meat products produced at facility # 97B because they may be contaminated with Lm
- August 24, 2008 – Recall → ML Foods voluntarily recalled all products manufactured at facility #97B in Toronto
- August 24, 2008 – Facility Closure → Toronto ML facility #97B was shut down and disinfection of the entire plant commenced

Environmental Investigation

- Maple Leaf Foods Establishment 97B had several production lines that produced a variety of ready-to-eat meat products, including Sure Slice brand products which were distributed nationally
- The Sure Slice brand included 6 different types of deli-meats and was marketed primarily to hotels, restaurants and institutions including hospitals and homes for the aged

The Strain

- Three distinct, but highly-related strains, may have been involved in the outbreak
- Two isolates were found to harbour a 50 kbp putative mobile genomic island encoding translocation and efflux functions, that have not been observed in other Listeria genomes

Reference Outbreak Strain

- Serotype 1/2a
- PFGE type (LMACI.0040, LMAAI.0001)
- Ribotype (DUP-1045)
- Lineage II
- Clonal complex 8; ST 120
- Related to ECIII

Prophage accounts for PFGE variation
Before 2008 Outbreak –
Tracking the number of positive sites and making sure that everyone was sanitized

NOW:
- Daily, scientific analysis to look for repeat patterns and root causes,
- Complete management oversight and quarantine procedures

Trend Analysis - Expectations

Weight of Evidence
The simplified process of decision-making is, as follows:

Microbiology  Epidemiology  Environmental Assessment  
Weight of Evidence  Health Risk Assessment  Action

Useful information


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<table>
<thead>
<tr>
<th>Date</th>
<th>Title</th>
<th>Speaker</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 Sep</td>
<td>Upcoming Teleclasses First Teleclass Vignette at CHEA - part 1</td>
<td>Speaker: Community and Hospital Infection Control Association of Canada Board Members and Guests</td>
</tr>
<tr>
<td>30 Sep</td>
<td>Prevention of Mother to Child Transmission of HIV</td>
<td>Speaker: Dr. Kay Libans, University of Missouri</td>
</tr>
<tr>
<td>13 Oct</td>
<td>Origin: Pacific Teleclass Infection Control in the Pacific</td>
<td>Speaker: Claire Boardman, YCNISS, Australia</td>
</tr>
<tr>
<td>21 Oct</td>
<td>Methods of Mobilizing Hand Hygiene: Frequency and Compliance</td>
<td>Speaker: Dr. John Boyce, Hospital of St. Raphael</td>
</tr>
<tr>
<td>26 Oct</td>
<td>Implementing Infection Prevention for Healthcare Workers</td>
<td>Speaker: Dr. Ruth Woolley, Washington University School of Medicine</td>
</tr>
<tr>
<td>04 Nov</td>
<td>Living Socially: Prevent Healthcare Associated Infection</td>
<td>Speaker: Dr. Hugo Sex, University of Geneva Hospitals, Schweitzerland</td>
</tr>
</tbody>
</table>