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Safe Foods for Ontarians: Challenges and Opportunities

Mansel W. Griffiths
University of Guelph
"It started out with lactose, but now he's intolerant of everything."
Food Safety Is An Ongoing Problem

- Increase in susceptible individuals
  - Aging population – baby boomers
  - Autoimmune diseases
  - Immunosuppressive therapies

- Changes in production/processing

- Increased globalization

- Increased number of meals outside the home

- Motile populations

- Changing microbes
  - AMR
  - O104

- Increased consumer awareness and media attention
### Who is at risk of foodborne infection?

<table>
<thead>
<tr>
<th>Host factors</th>
<th>Reasons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary immunodeficiencies</td>
<td>Immune system inadequate to combat infection</td>
</tr>
<tr>
<td>Immunocompromised persons, including those treated with chemotherapy or radiation therapy, recipients of transplants taking immunosuppressive drugs, persons with leukemia, persons with diseases of the immune system, AIDS patients</td>
<td>Immune system inadequate to combat infection</td>
</tr>
<tr>
<td>Excessive iron in blood</td>
<td>High levels of iron increase growth of certain pathogens</td>
</tr>
<tr>
<td>Cirrhosis and other liver disease, kidney function (alcoholism)</td>
<td>Iron overload, immune system dysfunction</td>
</tr>
<tr>
<td>Stress, e.g., as a result of surgery</td>
<td>Changes in metabolism reduce resistance to infection</td>
</tr>
<tr>
<td>Pregnancy</td>
<td>Altered immunity</td>
</tr>
<tr>
<td>Age &lt;5 years</td>
<td>Lack of developed immune system, smaller infective dose required for infection</td>
</tr>
<tr>
<td>Age 60–65 years</td>
<td>Immune system deteriorating, also affected by chronic ailments</td>
</tr>
<tr>
<td>Nutritional deficiency, e.g., through poor absorption of food, poor nutrition, or starvation</td>
<td>Inadequate immune system</td>
</tr>
<tr>
<td>Consumption of antacids, particularly proton pump inhibitors</td>
<td>Increase pH in stomach, increasing survival of pathogens</td>
</tr>
<tr>
<td>Consumption of large volumes of liquids, including water</td>
<td>Dilution of acids in the stomach, rapid transit through stomach</td>
</tr>
<tr>
<td>Ingestion of fatty foods (e.g., chocolate, cheese, hamburger) containing pathogens</td>
<td>Fat protects pathogens from acid in stomach</td>
</tr>
</tbody>
</table>

Modified from CAST (1994).
AIDS, acquired immune-deficiency syndrome.

From Lund & O'Brien 2011
The Well-Traveled Salad. Do You Know Where Your Food Has Been?

As consumers, many of us fail to recognize that even our domestic and local food supplies are part of a global network. The daily activity of consuming food directly links our health as humans to the health of crops and produce, food animals, and the environments in which they are produced.

A “One Health” approach to food safety—bringing together expertise and resources from the clinical, veterinary, wildlife health, and ecology communities—has the potential to reveal the sources, pathways, and factors driving the outbreaks of foodborne illness and possibly prevent them from occurring in the first place.

NOTE: Countries are listed in alphabetical order and not by volume of export.
Global examples of emerging and re-emerging infectious diseases.

70% are vector borne or zoonotic
Changes in geographic location

- *V. cholerae* in southeastern states of the US
- *V. vulnificus* in northeastern US
- *Cyclospora cayatenensis* in US and Canada
- Avian influenza
- Dengue fever
- Blue-tongue disease
Movement of blue-tongue disease

Importance of climate change
What problems do we face?
CFIA Recalls - 2014

- Total of 238 recalls (Figures include recall updates)
  - 188 Class 1 (serious health risk)
  - 47 Class 2 (possible health risk)
  - 3 Class 3 (no health risk)

- Reasons for recalls:
  - Allergens – 139 recalls
  - Potential contamination with pathogens – 88 recalls
    - *Staph. aureus* – 7
    - *C. botulinum* – 8
    - STEC – 13 (2 *E. coli* O26)
    - *Salmonella* – 29
    - *Listeria* – 31
  - Foreign objects – 5 recalls
  - Others – 6 (including packaging defects (1), improper storage and inspection (3), spoilage (1), and chemical contamination (1))
Foods Implicated in Recalls due to Pathogens

- Sprouts, flax/chia seeds and pumpkin seed pesto
- Breakfast wraps and sandwiches
- Garlic and cheese bread
- Caramel apples
- RTE meats
- Ground beef, beef balls, frozen and fresh pork and ground chicken
- Salads
- Cheeses (including aged Cheddar)
- Liver pate, bacon spread and lobster paste
- Chicken breast strips
- Soft fruits (peaches, plums) and fruit salad
- Chia and berry fruit and nut bars
- Smoked fish
- Frozen lollipops
- Stir fry vegetables
- Cranberry-apple cider
- Hummus and tahini
- Herbs and spices
  - Oregano, rosemary, white pepper, peppercorns, carob powder, paprika
- Prosciutto and salami
- Almond and peanut butters
- Cole slaw
- Mushrooms
- Dried egg
- Rice porridge with abalone

US, Italy, France, Greece, China, Viet Nam, Portugal, Lebanon, Australia, Korea
What is being done?

- Safe Foods for Canadians Act
  - Licence food importers holding them accountable for the safety of the food commodities they bring into the country.

- US Food Safety Modernization Act
  - Requires importers of food to have a foreign supplier verification program (FSVP) to verify that foreign suppliers are producing food in compliance with food safety regulations.

- EU
  - Food products of animal origin are allowed into the European Union only if they come from an approved establishment in a third country.
What is required?

- Certify as close to source as possible
- Traceability
  - Global Food Traceability Center
  - Centre for Food in Canada
- Smartphone apps
  - Origin of product
  - Product freshness
  - Packaging information
  - Nutrition and allergen facts
  - Food recall information
Other problems!

- Pathogens won’t behave themselves
- Consumer quest to live forever
- Farmers and processors need to make money
- Too many people, too few resources
What are emerging pathogens?

- Increased incidence of disease over 20 years
- New infections due to changes in existing organisms
- Infections spreading to new locations or populations
- Old infections arising from new vehicles
- Agents previously unrecognized as pathogens
Why do pathogens emerge?

- Microbial adaptation and change
- Host factors
  - Aging populations
  - Susceptibility to illness
- Environmental factors (e.g. weather)
- Changing niches
- Global trade and travel
- Changing agricultural and manufacturing practices
- Political and social factors
How big is the problem?

Cases
- Known: 20%
- Unknown: 80%

Deaths
- Known: 56%
- Unknown: 44%

Scallan et al. 2011
Increasing complexity

- 1978: New disease identified every 10 - 15 years
- 1988: New disease identified every 8 - 9 years
- Now: New disease identified every 14 - 16 months
- Estimated that zoonotic pathogens 2× as likely to be linked to emerging diseases

Farber 2008
Major pathogens identified since 1970

**Bacterial**
- *Arcobacter butzleri*
- *Campylobacter jejuni*
- *Campylobacter fetus*
- *Cronobacter sakazakii*
- *E. coli* O157:H7*
- *E. coli*, non-O157 STEC*
- *E. coli*, enteroaggregative/STEC*
- *E. coli*, other diarrheagenic
- *Listeria monocytogenes*
- *Vibrio cholerae* O139, toxigenic*
- *Vibrio vulnificus*
- *Vibrio parahaemolyticus*
- *Yersinia enterocolitica*
- *Yersinia pseudotuberculosis*

**Algal**
- *Pseudo-nitzschia pungens* (domoic acid-producing)

**Parasitic**
- *Cryptosporidium*
- *Cyclospora cayetanensis*
- *Sarcocystis*
- *Trypanosoma cruzi*

**Viral**
- Astrovirus
- Caliciviridae (norovirus and sapovirus)
- Hepatitis E*
- Nipah virus*
- Rotavirus

**Fungal**
- *Aspergillus flavus* aflatoxin

**Prion Agent**
- new Variant Creutzfeld Jacob Disease prion*

Behravesh CB, Williams IT, Tauxe RV. EMERGING FOODBORNE PATHOGENS AND PROBLEMS: EXPANDING PREVENTION EFFORTS BEFORE SLAUGHTER OR HARVEST. National Academies Press (US); 2012.
What infections are on the increase?

- Foodborne viruses
  - Norovirus
  - Rotavirus
  - Hepatitis E
Norovirus

- Leading cause of gastroenteritis
  - >50% of all foodborne infections

- Globally each year accounts for:
  - >1 million hospitalizations
  - 200,000 deaths in children under 5 years old

- Genotype II.4 is most prevalent and has been detected in retail meats
Rotavirus

- Acute gastroenteritis in children
- Highly infective through fecal oral route
- 138 million cases and 600,000 deaths each year worldwide
- Oral vaccine available
- Group A rotavirus found in 18% of raw meat (poultry, beef or pork) in Canada
Hepatitis E

- Drinking water in Asia, Africa and S. America
- High mortality rate in certain populations
  - 20% in pregnant women and 1-3% overall
- Increase in illness in several countries
- Pigs may be reservoir
How are organisms changing?

- Acquisition of new virulence factors
- Acquisition of antimicrobial resistance
- Resistance to environmental factors e.g. acid
Shiga-toxin producing *E. coli* (STEC)

- Produce exotoxin
- Vary in their ability to cause disease
- “Big six” non-O157 STECs
  - O26; O45; O103; O111; O121; O145
- Required to test for O157 + “big six”
Vehicles for Non-O157 infections

Figure 1. Outbreaks of non-O157:H7 STEC associated with known vehicles.

- Water (11%)
- Person-to-person (38%)
- Dairy (11%)
- Produce (6%)
- Meat (15%)
- Other food (11%)
- Animal contact (8%)

Figure 2. Outbreak cases of non-O157:H7 STEC associated with known vehicles.

- Water (7%)
- Person-to-person (25%)
- Dairy (5%)
- Produce (9%)
- Meat (15%)
- Other food (35%)
- Animal contact (4%)

Kaspar et al. 2010
**E. coli O104:H4**

- An enteroaggregative strain that has acquired shiga-toxin genes
- Outbreak in Germany in 2011 linked to fenugreek seeds
- 3,950 cases and 53 deaths
- 1 in 4 cases developed HUS
- Affected young, healthy adults
Old friends - New places

**Salmonella Outbreaks in Low-Moisture Products**

<table>
<thead>
<tr>
<th>Year</th>
<th>Product</th>
<th>Serotype</th>
<th>Country</th>
<th>Cases</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000-01</td>
<td>Raw almonds</td>
<td>Enteritidis</td>
<td>US/Canada</td>
<td>168</td>
<td>Eurosurveillance vol12 issue 3-6</td>
</tr>
<tr>
<td>2002</td>
<td>Tahini, Halva</td>
<td>Montevideo</td>
<td>Australia</td>
<td>55</td>
<td>Eurosurveillance Vol 7 Issue 38</td>
</tr>
<tr>
<td>2003-04</td>
<td>Raw almonds</td>
<td>Enteritidis</td>
<td>US/Canada</td>
<td>29</td>
<td>MMWR 53(22);484-487</td>
</tr>
<tr>
<td>2006-07</td>
<td>Peanut butter</td>
<td>Tennessee</td>
<td>US</td>
<td>628</td>
<td>MMWR 56(21);521-524</td>
</tr>
<tr>
<td>2008-09</td>
<td>Peanut butter</td>
<td>Typhimurium</td>
<td>US</td>
<td>691</td>
<td>CDC, March 17, 2001</td>
</tr>
</tbody>
</table>

Adapted from Scott, (2009) IAFP
Old friends – New Places

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>E. coli</em> O157:H7</td>
<td>Haggis, melons, fermented meats, apple juice, cookie dough, pizza</td>
</tr>
<tr>
<td><em>Salmonella</em></td>
<td>Tomatoes, melons, mango</td>
</tr>
<tr>
<td><em>Listeria monocytogenes</em></td>
<td>Melon, caramel apples</td>
</tr>
<tr>
<td><em>Cyclospora cayatenensis</em></td>
<td>Raspberries, basil, snow peas</td>
</tr>
<tr>
<td><em>Clostridium botulinum</em></td>
<td>Carrot juice</td>
</tr>
<tr>
<td><em>Campylobacter</em></td>
<td>Snow peas</td>
</tr>
<tr>
<td><em>Shigella</em></td>
<td>Sugar snap peas, baby corn</td>
</tr>
<tr>
<td>Hepatitis A</td>
<td>Watercress, green onions, frozen strawberries</td>
</tr>
<tr>
<td>Norovirus</td>
<td>Fresh-cut fruit, bread, pasteurized milk</td>
</tr>
</tbody>
</table>
Distribution of illnesses caused by a single food type reported to CDC's National Foodborne Disease Outbreak Surveillance System, 2003-2008
Fifteen New Food Vehicles associated with Foodborne Outbreaks from 2006 Through March 2012 in the United States

- Bagged spinach
- Pasteurized carrot juice
- Peanut butter
- Broccoli powder on a children's snack food
- Dry dog food
- Frozen pot pies
- Canned chili sauce
- Hot peppers
- White and black pepper
- Raw cookie dough (likely flour)
- Hazelnuts
- Fenugreek sprouts
- Papayas
- Pine nuts
- Raw frozen scraped ground tuna

Behravesh CB, Williams IT, Tauxe RV. EMERGING FOODBORNE PATHOGENS AND PROBLEMS: EXPANDING PREVENTION EFFORTS BEFORE SLAUGHTER OR HARVEST. National Academies Press (US); 2012.
New Friends – Old Places

- MRSA
  - 1% of population in US are asymptomatic carriers
  - Disease affects 32/100,000 population
  - Present in a variety of foods including pork, beef and dairy products (including mozzarella in Italy)
  - Foodborne outbreaks are rare but have occurred
New Friends – Old Places

- *Clostridium difficile*
  - Increasing prevalence of serotype responsible for community acquired infection in several countries
  - Isolated from animals (including cattle and pigs) and a variety of foods including retail ground meat (20% +ve in 2005 Canadian survey), raw vegetables and ready-to-eat salads
  - Similarities in isolates from humans, animals and foods
  - Spores survive 71°C for >120 minutes
**C. difficile - Animals**

**Table 1. Prevalence of isolation and ribotype distribution of Clostridium difficile from food animals and retail meat**

<table>
<thead>
<tr>
<th>Country</th>
<th>Sample type</th>
<th>Prevalence (%)</th>
<th>Ribotype 027/ toxinoype III (%)</th>
<th>Ribotype 078/ toxinoype V (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada [34]</td>
<td>Calves</td>
<td>15</td>
<td>12</td>
<td>26</td>
</tr>
<tr>
<td>USA [33]</td>
<td>Calves</td>
<td>25</td>
<td>0</td>
<td>94</td>
</tr>
<tr>
<td>Canada [40]</td>
<td>Veal calves</td>
<td>49</td>
<td>0/1</td>
<td>65</td>
</tr>
<tr>
<td>Slovenia [61]</td>
<td>Calves</td>
<td>1.8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Austria [49]</td>
<td>Cows</td>
<td>4.5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Slovenia [36]</td>
<td>Chickens</td>
<td>62</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Austria [49]</td>
<td>Chickens</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Zimbabwe [62]</td>
<td>Chickens</td>
<td>29</td>
<td>NT</td>
<td>NT</td>
</tr>
<tr>
<td>Slovenia [61]</td>
<td>Piglets</td>
<td>52</td>
<td>0</td>
<td>0/77</td>
</tr>
<tr>
<td>USA [32]</td>
<td>Piglets</td>
<td>79</td>
<td>NT</td>
<td>NT</td>
</tr>
<tr>
<td>USA [63]</td>
<td>Piglets</td>
<td>NA</td>
<td>0</td>
<td>83</td>
</tr>
<tr>
<td>Austria [49]</td>
<td>Pigs</td>
<td>3.3</td>
<td>0</td>
<td>0/50</td>
</tr>
<tr>
<td>Canada [37]</td>
<td>Piglets</td>
<td>95</td>
<td>0</td>
<td>94</td>
</tr>
<tr>
<td>Canada [44]</td>
<td>Beef, veal</td>
<td>20</td>
<td>0/67</td>
<td>0</td>
</tr>
<tr>
<td>USA [23]</td>
<td>Various</td>
<td>42</td>
<td>27</td>
<td>73</td>
</tr>
<tr>
<td>Canada [45]</td>
<td>Beef, veal</td>
<td>6.1</td>
<td>0/27</td>
<td>0</td>
</tr>
<tr>
<td>Canada [46]</td>
<td>Pork</td>
<td>1.8</td>
<td>43/57</td>
<td>0</td>
</tr>
<tr>
<td>Canada [47]</td>
<td>Chicken</td>
<td>15</td>
<td>0</td>
<td>96</td>
</tr>
<tr>
<td>Canada [48]</td>
<td>Pork</td>
<td>12</td>
<td>7.1/14</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td>Beef</td>
<td>12</td>
<td>7.1</td>
<td>86</td>
</tr>
</tbody>
</table>

NT, typing was not performed; NA, not applicable, as the study was an evaluation of previously collected isolates.
# C. difficile - Food

<table>
<thead>
<tr>
<th>Country (region), product</th>
<th>No. of positive samples/total no. cultured (%)</th>
<th>PCR ribotype</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States (Arizona)</td>
<td></td>
<td></td>
<td>[10]</td>
</tr>
<tr>
<td>Ground beef</td>
<td>13/26 (50.0)</td>
<td>027, 078</td>
<td></td>
</tr>
<tr>
<td>Summer sausage</td>
<td>1/7 (14.3)</td>
<td>027</td>
<td></td>
</tr>
<tr>
<td>Ground pork</td>
<td>3/7 (42.9)</td>
<td>027, 078</td>
<td></td>
</tr>
<tr>
<td>Braunschweiger</td>
<td>10/16 (62.5)</td>
<td>027, 078</td>
<td></td>
</tr>
<tr>
<td>Chorizo</td>
<td>3/10 (30)</td>
<td>027, 078</td>
<td></td>
</tr>
<tr>
<td>Pork sausage</td>
<td>3/13 (23.1)</td>
<td>027, 078</td>
<td></td>
</tr>
<tr>
<td>Ground turkey</td>
<td>4/9 (44.4)</td>
<td>078</td>
<td></td>
</tr>
<tr>
<td>Canada (Ontario, Quebec)</td>
<td></td>
<td></td>
<td>[11]</td>
</tr>
<tr>
<td>Ground beef</td>
<td>11/53 (20.8)</td>
<td>077, M31, 014, M26</td>
<td></td>
</tr>
<tr>
<td>Ground veal</td>
<td>1/7 (14.3)</td>
<td>M31</td>
<td></td>
</tr>
<tr>
<td>Canada (nationwide)</td>
<td></td>
<td></td>
<td>[12]</td>
</tr>
<tr>
<td>Ground beef</td>
<td>10/149 (6.7)</td>
<td>M26, 077, J, 014, C, F, H</td>
<td></td>
</tr>
<tr>
<td>Veal chops</td>
<td>3/65 (4.6)</td>
<td>M26, J, K</td>
<td></td>
</tr>
<tr>
<td>Canada (British Columbia, Saskatchewan, Ontario, Quebec)</td>
<td></td>
<td></td>
<td>[13]</td>
</tr>
<tr>
<td>Ground beef</td>
<td>14/115 (12.2)</td>
<td>078, 027, C</td>
<td></td>
</tr>
<tr>
<td>Ground pork</td>
<td>14/115 (12.2)</td>
<td>078, 027, C, E, Y</td>
<td></td>
</tr>
<tr>
<td>Scotland</td>
<td></td>
<td></td>
<td>[14]</td>
</tr>
<tr>
<td>Salad</td>
<td>3/40 (7.5)</td>
<td>017, 001</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE.** PCR, polymerase chain reaction.

L. Hannah Gould, and Brandi Limbago Clin Infect Dis. 2010;51:577-582

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Greater virulence?

- *Salmonella* Typhimurium DT104
  - Antimicrobial resistance genes carried on chromosome
  - Isolated from wide variety of animals
  - UK reports indicate severe clinical signs including septicemia, which resulted in hospitalization among 41% and death in 3% of patients.

- *Campylobacter jejuni* clone SA
  - Leading cause of abortion in sheep in US
  - Highly virulent
  - Tetracycline resistant
New *C. jejuni*?

TABLE 1 Human *C. jejuni* isolates indistinguishable by PFGE from clone SA identified in the PulseNet National *Campylobacter* database at the CDC through 2010

<table>
<thead>
<tr>
<th>Case</th>
<th>No. of isolates</th>
<th>State</th>
<th>Yr</th>
<th>Isolation source</th>
<th>Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outbreak 1</td>
<td>1</td>
<td>VT</td>
<td>2003</td>
<td>Unknown</td>
<td>Raw milk</td>
</tr>
<tr>
<td>Outbreak 2</td>
<td>4</td>
<td>SC</td>
<td>2007</td>
<td>Stool</td>
<td>Raw milk</td>
</tr>
<tr>
<td>Outbreak 3</td>
<td>16&lt;sup&gt;a&lt;/sup&gt;</td>
<td>PA</td>
<td>2008</td>
<td>Unknown</td>
<td>Raw milk</td>
</tr>
<tr>
<td>Outbreak 4</td>
<td>4</td>
<td>RI</td>
<td>2008</td>
<td>Unknown</td>
<td>Chicken</td>
</tr>
<tr>
<td>Outbreak 5</td>
<td>32</td>
<td>WI</td>
<td>2009</td>
<td>Stool</td>
<td>Raw milk</td>
</tr>
<tr>
<td>Outbreak 6</td>
<td>2</td>
<td>MA</td>
<td>2010</td>
<td>Stool/blood</td>
<td>Raw milk</td>
</tr>
<tr>
<td>Outbreak 7</td>
<td>7</td>
<td>MI</td>
<td>2010</td>
<td>Stool</td>
<td>Raw milk</td>
</tr>
<tr>
<td>Outbreak 8</td>
<td>1</td>
<td>MT</td>
<td>2010</td>
<td>Unknown</td>
<td>Well water</td>
</tr>
<tr>
<td>Outbreak 9</td>
<td>2</td>
<td>VT</td>
<td>2010</td>
<td>Stool</td>
<td>Raw milk</td>
</tr>
<tr>
<td>Sporadic&lt;sup&gt;b&lt;/sup&gt;</td>
<td>56</td>
<td>Multiple</td>
<td>2004–2010</td>
<td>Stool</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

<sup>a</sup> Includes two raw milk isolates from the dairy implicated in the outbreak.

<sup>b</sup> Sporadic cases were from multiple states (Arkansas, Colorado, Kansas, Massachusetts, Utah, Sout Dakota, Vermont, Wisconsin, and Wyoming); the isolates were mainly from stool samples (except a few from blood or unknown origin), and sources of exposure were unknown for most cases (raw milk was implicated in one case).

From Sahin *et al.* 2012
# Mortality 1 year after infection


<table>
<thead>
<tr>
<th>Organism</th>
<th>Relative mortality compared to control</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Salmonella (all)</strong></td>
<td>2.85</td>
</tr>
<tr>
<td>Enteritidis</td>
<td>2.83</td>
</tr>
<tr>
<td>Typhimurium</td>
<td>2.88</td>
</tr>
<tr>
<td>Typhimurium (drug resistant)</td>
<td>2.3 – 10.3*</td>
</tr>
<tr>
<td>Dublin</td>
<td>12.35</td>
</tr>
<tr>
<td>Other</td>
<td>2.5</td>
</tr>
<tr>
<td><strong>Campylobacter</strong></td>
<td>1.86</td>
</tr>
<tr>
<td><strong>Yersinia</strong></td>
<td>2.1</td>
</tr>
<tr>
<td><strong>Shigella</strong></td>
<td>1.8</td>
</tr>
</tbody>
</table>

* Relative mortality increases for strains with broader spectrum of resistance
What can we do to combat emerging infections?

- Better understand the routes of transmission, ecology and pathogenicity
- Surveillance
- Industry should keep abreast of the developments and outbreaks
- Build food safety into the product development process
- Be cognizant of how changes in formulation can affect exotic pathogens
  - Botulism and yoghurt – change from sugar to aspartame
What can we do to combat emerging infections?

- When new vehicles are identified make sure these are incorporated into the Hazard Identification if applicable.

- Review possible consumer use
  - e.g. S. Agona in herbal tea

- Risk assessments available for less common pathogen/food combinations
  - e.g., Cryptosporidium; Cronobacter; L. mono/ice cream
Good Risk Assessments

‘I will now be fired into a tank of baby milk while eating this beef sandwich’
Keep doing what we are doing

- Emphasis on GMP/HACCP
  - Behaviour-based Food Safety

- Water quality

- Raw material quality

- Emphasis Environmental Monitoring Programs
# Outbreaks linked to environmental contamination

<table>
<thead>
<tr>
<th>Product</th>
<th>Pathogen</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuna salad</td>
<td><em>C. jejuni</em></td>
<td>Probably chicken handled in same kitchen</td>
</tr>
<tr>
<td>Ice cream</td>
<td><em>S. enteritidis</em></td>
<td>Pasteurized ice cream mix in tanker truck previously used for transporting raw liquid eggs</td>
</tr>
<tr>
<td>Infant formulae</td>
<td><em>S. ealing</em></td>
<td>Contamination from the processing environment, insulation material of the drying tower</td>
</tr>
<tr>
<td>Soft cheese</td>
<td><em>S. berta</em></td>
<td>Cheese ripening in buckets previously used for chicken carcasses</td>
</tr>
<tr>
<td>Cooked sliced ham</td>
<td><em>S. typhimurium</em></td>
<td>Cooked ham placed into containers previously used for curing</td>
</tr>
<tr>
<td>Chocolate</td>
<td><em>S. Napoli</em></td>
<td>Possibly contaminated water used in double-walled pipes, tanks</td>
</tr>
<tr>
<td>Chocolate</td>
<td><em>S. eastbourne</em></td>
<td>Contamination from the processing environment</td>
</tr>
<tr>
<td>Butter</td>
<td><em>L. monocytogenes</em></td>
<td>Contamination from the processing environment</td>
</tr>
<tr>
<td>Hot dogs</td>
<td><em>L. monocytogenes</em></td>
<td>Contamination from the processing environment</td>
</tr>
<tr>
<td>Canned salmon</td>
<td><em>C. botulinum</em></td>
<td>Contamination from the processing environment, cooling water</td>
</tr>
<tr>
<td>Lasagne</td>
<td><em>S. aureus</em></td>
<td>Growth of <em>S. aureus</em> in the processing equipment, improper cleaning</td>
</tr>
<tr>
<td>Different foods</td>
<td><em>E. coli</em> O157:H7</td>
<td>Contaminated meat grinder and equipment at retail level</td>
</tr>
<tr>
<td>Chocolate milk</td>
<td><em>Y. enterocolitica</em></td>
<td>Probably during manual mixing of pasteurized milk and chocolate</td>
</tr>
<tr>
<td>Canned meat</td>
<td><em>S. typhi</em></td>
<td>Use of non-potable water for can cooling</td>
</tr>
<tr>
<td>Crabmeat</td>
<td><em>S. aureus</em></td>
<td>Contamination during manual picking of cooked meat</td>
</tr>
<tr>
<td>Canned mushrooms</td>
<td><em>S. aureus</em></td>
<td>Possible growth of <em>S. aureus</em> in the brine bath before canning</td>
</tr>
<tr>
<td>Flavored yogurt</td>
<td><em>E. coli</em> O157:H7</td>
<td>Pump previously used for raw milk</td>
</tr>
<tr>
<td>Pastry</td>
<td><em>S. Enteritidis</em> PT4</td>
<td>Equipment previously used for raw eggs or insufficiently cleaned piping and nozzles used for cream</td>
</tr>
<tr>
<td>Yeasts</td>
<td><em>S. munchen</em></td>
<td>Contamination from the processing environment</td>
</tr>
<tr>
<td>Pasteurized milk</td>
<td><em>S. typhimurium</em></td>
<td>Possibly cross-connection between raw and pasteurized milk</td>
</tr>
<tr>
<td>Pasteurized milk</td>
<td><em>E. coli</em> O157:H7</td>
<td>Contamination from pipes and rubber seals of the bottling line</td>
</tr>
<tr>
<td>Pasteurized milk</td>
<td><em>B. cereus</em></td>
<td>Filling equipment</td>
</tr>
<tr>
<td>Pasteurized milk</td>
<td><em>Y. enterocolitica</em></td>
<td>Post-process contamination</td>
</tr>
<tr>
<td>Mexican type cheese</td>
<td><em>L. monocytogenes</em></td>
<td>Contamination from the processing environment</td>
</tr>
</tbody>
</table>

Adapted from Reij and Aantrekker (2004); and ICMSF (2002).
Causes of Foodborne Illness

Fig. 3.3 Contributory faults reported in outbreaks in selected countries reporting to the WHO programme for foodborne infections and intoxications in Europe.
Five keys to safer food

Keep clean
- Wash your hands before handling food and after doing food preparation.
- Wash your hands after using the toilet.
- Wash and sanitise all surfaces and equipment used for food preparation.
- Protect food areas and keep food free from insects, pests and other animals.

Why?
- Poor hygiene during food preparation can lead to the spread of harmful bacteria, viruses, and parasites.

Separate raw and cooked
- Separate raw and cooked food.
- Use separate equipment and utensils such as knives and cutting boards for handling raw and cooked food.
- Store food in containers to ensure no交叉 contamination between raw and cooked food.

Why?
- Cross-contamination can occur when raw and cooked food come into contact, leading to the growth of harmful bacteria.

Cook thoroughly
- Cook food thoroughly to ensure all microorganisms are destroyed.
- Temperature sensors and thermometers are used to check that the food reaches at least 75°C or 165°F.

Why?
- Cooking food to the correct temperature is essential to destroy harmful microorganisms and ensure food safety.

Keep food at safe temperatures
- Do not leave cooked food at room temperature for more than 2 hours.
- Do not reheat food that has cooled and returned to room temperature.
- Keep cooked food below 4°C or above 60°C.

Why?
- Storing food at unsafe temperatures can lead to the growth of harmful bacteria.

Use safe water and raw materials
- Use safe water or heat it to make it safe.
- Select fresh and wholesome food.

Why?
- Using safe water and selecting fresh and wholesome food is crucial for preventing foodborne illness.

Knowledge = Prevention
BUT We Must Start Learning from Our Mistakes!
1998: Lunchmates and *Salmonella*

- 805 Canadians, primarily children (>80% of cases <15 years old), contracted *S. Enteritidis* linked to Schneider's Lunchmates with 60 hospitalizations

- Ingredients for Lunchmates provided by several suppliers, and assembled at central plant for distribution

- Contaminated Cheddar cheese was traced to a plant supplying another plant where the product was shredded

- *Salmonella* was isolated from the cheese portion of pizza and taco products
Auditor General Report

• What did not work
  • Lack of timely exchange of information between provincial and federal agencies
    • Resulted in a delay in identification of outbreak
  • Laboratory Centre for Disease Control (LCDC; now NML) was ill-equipped to handle outbreaks
    • Confusion regarding who was responsible
  • CFIA did not share distribution data with provincial health agencies
    • Not all cases in Ontario appeared to be linked to cheese
Fast Forward 10 years

- Maple Leaf listeriosis outbreak
  - 57 cases of serious illness; 23 deaths
  - Mainly in elderly
  - Contamination of meat slicer at Bartor Road facility
  - Recall of 668,000kg of 191 meat products
  - Cost to the company was >$100 million
Weatherill Report

- 57 recommendations
  - Enhance food safety awareness among processors
  - Consolidate CFIA responsiveness
  - Improve Listeria policy
  - Improve food safety solutions
  - Enhance effectiveness and timeliness of CFIA responses
  - Protect vulnerable populations
  - Improve national foodborne emergency response
  - Enhance communications
  - Modernize federal regulatory food safety framework
What next?

XL Foods

XL Foods Brooks Plant was temporarily closed on September 27, 2012 by the CFIA because *E. coli* O157 was found on processed beef.

- Plant incorrectly testing for O157 so more stringent testing introduced.
- Plant processed 2,000 to 5,000 cattle per day, which represented about 35% of Canadian beef slaughtering capacity.
- A total of 18 confirmed cases of infection with *E. coli* O157:H7 were reported.
- 4,000,000 kg of beef recalled at a cost to the industry of between $16 to 27 million.
- The Brooks plant was sold to JBS Canada on January 14, 2013.
Review of outbreak (one lesson learnt)

- In February 2013, the Government of Canada appointed an Independent Expert Advisory Panel

“The greater element – and the greater *challenge* – of food safety is people. Systems are of no use without the skill, vigilance and commitment of individuals. The lion's share of our recommendations focus on this element”.
XL Review recommendations

Four major recommendations:
- Strengthen prevention strategies and regulatory oversight
- Strengthen surveillance and trend analysis
- Strengthen incident management and recall response
- Strengthen communication with the public and stakeholders
1998 to 2012: What didn’t we learn?

- How to analyse data
- How to communicate effectively
- How to respond effectively to crises
- How to get the best out of people
Food Safety is a People Problem

- Develop a strong food safety culture
  - Food Standards Agency Food Safety Culture Toolkit for Inspectors

- Training and continuing education of inspectors and industry
  - Safe Food Canada – The Learning Initiative
  - Company/University Initiatives
    - Loblaw Academy (now the Guelph Food Academy)
    - Maple Leaf Foundation
  - International Initiatives
    - Global Food Safety Partnership – IUFoST
Social Consequences

Sanlu milk powder

- Melamine contamination
- 6 children died and 300,000 people affected
- Two men sentenced to death by a Chinese court, two to life imprisonment and three sentenced to 5 – 15 years

Fish and Chips

A takeaway operator was jailed for eight months and banned from running food businesses after admitting hygiene offences which led to an *E. coli* outbreak.

School Meals

*E. coli* O157 outbreak led to death of Mason Jones. The butcher involved, William Tudor, was convicted after pleading guilty to 7 food hygiene offences sentenced to one year in prison. He was released after serving 12 weeks of that sentence.

Peanut Corporation of America/Jensen Farms

PCA Parnell brothers found guilty on multiple counts. Still awaiting sentencing

Jensen brothers pleaded guilty. Recommendation of probation
Food Standards Agency Categories of Food Safety Culture

- **Leaders**
  - View food hygiene as a critical business issue that they must tightly manage and offers potential business benefits...

- **Proactive compliers**
  - Management provide a lead in encouraging compliance for the sake of the business ...but may not go beyond “good practice”

- **Dependent compliers**
  - Wait upon advice or instruction from regulators and other third parties to make improvements...

- **Doubting compliers**
  - Doubt the significance of the risk posed by food hygiene and the effectiveness of food hygiene regulations...

- **Calculative non-compliers**
  - Intentionally breach regulations for the sake of financial gain...
# Changing Attitudes

<table>
<thead>
<tr>
<th>Safety culture category</th>
<th>Advice for enabling improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaders</td>
<td>Applaud and reinforce commitment to best practice</td>
</tr>
<tr>
<td>Proactive compliers</td>
<td>Applaud and encourage next steps</td>
</tr>
<tr>
<td>Dependent compliers</td>
<td>Encourage and enable self reliance</td>
</tr>
<tr>
<td>Doubting compliers</td>
<td>Convince and dispel doubts</td>
</tr>
<tr>
<td>Calculative non-compliers</td>
<td>Challenge and convert</td>
</tr>
</tbody>
</table>

Greenstreet Berman Ltd
The goal of the food safety professional should be to create a food safety culture, not a food safety program – Frank Yiannas
PLEASE WASH YOUR HANDS AFTER TOUCHING THE FOOD