What New Tools are Necessary in Food Safety to Detect and Prevent Foodborne Outbreaks from Farm to Fork?

Kathryn J. Boor, PhD
Ronald P. Lynch Dean
College of Agriculture and Life Sciences
Cornell University, Ithaca, NY
E-mail: kjb4@cornell.edu
Take home messages

• Foodborne illnesses have tremendous negative impacts on global health and potentially, on international trade
• Mitigation of food safety risks requires a systems approach, including development and use of appropriate tools by appropriately trained people who have a holistic understanding of the food system
• Innovative public-private partnerships (industry, government, academia) across the globe are needed to improve food safety
Outline

• **Global food safety challenges and scope of the problem**
• **A systems approach: appropriate tools**
• **Private-public partnerships for food safety**
  – Foundation for Food and Agriculture Research (FFAR)
  – US check-off dollar-based programs
• **Science-based decision making – the policy science interface**
The Major Causes of Foodborne Disease

Parasites
- *Giardia*
- Liver flukes
- *Toxoplasma*

Bacteria
- *Salmonella*
- *Campylobacter*
- *E. coli*

Chemicals (toxins)
- Cassava cyanide
- Aflatoxins
- Dioxins

Viruses
- Norovirus
- Hepatitis A
Global Foodborne Disease per year

- Illnesses: Approx. 600 million (95% Uncertainty Interval [UI]: 417 to 963 million)
- Deaths: approx. 420,000 (95% UI: 305,000 - 598,000)

Proportion from agent category

Source: adapted from WHO, 2015
Sequelae: not just an upset stomach

- Long-term sequelae associated with foodborne diseases
  - *Campylobacter*: Guillain-Barré Syndrome
  - *E. coli / Salmonella*: Reactive arthritis
  - Aflatoxin: Liver cancer
  - Shiga toxin-producing *E. coli* – renal disease
  - *Taenia solium*: epilepsy
  - Bacteria: cancer?

Source: Havelaar et al., 2015
PLOS Med 12(12)e1001923
Disease burden differs by region, but NTS and *Campylobacter* are ‘universal’ problems

Adapted from source: WHO, 2015
Figure 16. The global burden of foodborne disease by subregion (DALYS per 100 000 population) caused by enteric hazards, 2010.

Disease burden differs by geographic region:

- Africa
- Americas
- Eastern Mediterranean
- Europe
- South-East Asia
- Western Pacific

WHO, 2015
Children <5 yrs account for ~40% of foodborne disease burden
Economic impact of food contamination goes beyond public health associated costs

- Recalls of contaminated foods that have not been associated with human disease cases
- Trade associated impacts
Multistate Outbreak of Listeriosis Linked to Commercially Produced, Prepackaged Caramel Apples Made from Bidart Bros. Apples (Final Update)

This investigation is closed, and the shelf life of recalled products has passed. Read the Advice to Consumers to learn about products that were recalled.

Highlights

- Read the Advice to Consumers and Retailers>
- This outbreak appears to be over. However, recalled products may still be in people’s homes. Consumers unaware of the recalls could continue to eat the products and get sick.

At a Glance:

- Case Count: 35
- States: 12
- Deaths: 7
- Hospitalizations: 34

Malaysia bans imports of Gala, Granny Smith apples from the US
Outline

• Global food safety challenges and scope of the problem
• **A systems approach: appropriate tools**
• Private-public partnerships for food safety
  – Foundation for Food and Agriculture Research (FFAR)
  – US check-off dollar-based programs
• Science-based decision making – the policy science interface
How does food become contaminated?

1. Environment
   - Water, soil, etc.
   - Pets and wildlife

2. Food and Feed plants
   - Processing
   - Preparation Consumption
   - Foodborne
   - Human
   - Human-human

3. Food animals
   - Processing
   - Direct animal contact

Source: WHO, 2015
Food Safety News

Breaking news for everyone’s consumption

Lawsuit Filed In Rocky Ford Cantaloupe Listeria Outbreak

By Dan Flynn | September 16, 2011

First came the state warning, then retail removals, next was the recall, followed by national warnings, and now the first lawsuit. The multi-state Listeria outbreak has played out this week like a carefully choreographed dance. And it is not over.

Jensen Farms, the Holly, CO-based grower of Rocky Ford cantaloupes, and Wal-Mart Stores Inc. were sued Thursday by Colorado Springs residents Charles and Tammy Palmer.

“Wal-Mart, Jensen Farms, and other food companies have a public responsibility to all consumers to sell and distribute food that is free and clear of dangerous adulterants such as Listeria —no exceptions,” said the Palmer family's attorney, William Marler. “In this case, a lapse in food safety assurance has relegated an innocent man to a hospital bed for a long time.”
E. coli outbreak linked to flour

CRF Frozen Foods Expands Voluntary Recall to Include All Frozen Vegetable and Fruit Products Due To Possible Health Risk

For Immediate Release

May 2, 2016
C.D.C. Ends Chipotle Case With Illness Still a Mystery

By CHRISTINE HAUSER  FEB. 1, 2016
“DNA fingerprinting”
Case study – human listeriosis outbreak
Human listeriosis cases in NYS: 1/97-10/98

- January 1997: 1 case
- February 1997: 0 cases
- March 1997: 2 cases
- April 1997: 0 cases
- May 1997: 1 case
- June 1997: 3 cases
- July 1997: 5 cases
- August 1997: 0 cases
- September 1997: 0 cases
- October 1997: 0 cases
- November 1997: 1 case
- December 1997: 0 cases
- January 1998: 2 cases
- February 1998: 0 cases
- March 1998: 1 case
- April 1998: 0 cases
- May 1998: 1 case
- June 1998: 0 cases
- July 1998: 0 cases
- August 1998: 0 cases
- September 1998: 0 cases
- October 1998: 0 cases
Subtyping results

<table>
<thead>
<tr>
<th>ID</th>
<th>Subtype</th>
</tr>
</thead>
<tbody>
<tr>
<td>B98-2192</td>
<td>DUP-1039</td>
</tr>
<tr>
<td>B98-3297</td>
<td>DUP-1045</td>
</tr>
<tr>
<td>B98-3556</td>
<td>DUP-1042</td>
</tr>
<tr>
<td>B98-3853</td>
<td>DUP-1052</td>
</tr>
<tr>
<td>B98-4054</td>
<td>DUP-1044</td>
</tr>
<tr>
<td>B98-3412</td>
<td>DUP-1044</td>
</tr>
<tr>
<td>B98-4051</td>
<td>DUP-1044</td>
</tr>
<tr>
<td>B98-4193</td>
<td>DUP-1044</td>
</tr>
</tbody>
</table>
Epidemic curve for 1/97 - 2/99 in NYS

- **1044A**
- **Other Ribotypes**
Nationwide outbreak of listeriosis due to contaminated meat

with strains yielding different patterns were used as controls. A total of 108 cases were identified with 14 associated deaths and four miscarriages or stillbirths. A case-control study implicated meat frankfurters as the likely source of infection (OR 17.3, 95% CI 2.4–160). The outbreak

Outbreak traced back to a single specific plant in Michigan

Plant had an appropriate HACCP plan

*L. monocytogenes* source was post-CCP contamination from the plant environment
PulseNet allows (international) outbreak detection and traceback. Food isolate, deposited into PulseNet.

Human case

Human case
DNA sequencing-based subtyping

<table>
<thead>
<tr>
<th>Isolate 1</th>
<th>AACATGCAGACTGACGATTCGACGTTGACTG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolate 2</td>
<td>AACATGCAGACTGACGATTCGC\textcolor{red}{T}GAGGCTAGACGTTGACTG</td>
</tr>
<tr>
<td>Isolate 3</td>
<td>AACATGCAGACTGACGATTCGACG\textcolor{red}{G}CTAGACGTTGACTG</td>
</tr>
<tr>
<td>Isolate 4</td>
<td>AACATGCA\textcolor{red}{T}ACTGACGATTCGACG\textcolor{red}{A}AGGCTAGACGTTGACTG</td>
</tr>
</tbody>
</table>
Food Safety News

CDC/FDA Partnership Targets Whole Genome Sequencing of Listeria Monocytogenes

By Brian Saunders | November 27, 2013

In a prior APHLTech blog post (NGS in Action: FDA’s Genome TRAKR Network), Victor Waddell of the Arizona State Public Health Laboratory described the newly formed network of laboratories formed by the U.S. Food and Drug Administration (FDA). Known collectively as Genome TRAKR, the member laboratories perform whole genome sequencing (WGS) on bacterial foodborne pathogens isolated primarily from food and environmental sources.

On Sept. 1, 2013, the Centers for Disease Control and Prevention (CDC) began a partnership with the FDA Genome TRAKR network to utilize the network to conduct WGS of all Listeria monocytogenes collected from reported human illness cases in the United States. This effort leverages public health resources to evaluate and
The genome sequence revolution
In addition, whole genome sequencing showed that 5 Listeria isolates collected in 2010 from the same facility were also closely related genetically to isolates from ill people.
Listeria Outbreaks and Incidence, 1983-2014

Outbreaks per year

- Pre-PulseNet: 0.3 outbreaks per year
- Early PulseNet: 2.3 outbreaks per year
- Listeria Initiative: 2.9 outbreaks per year
- WGS: 10 outbreaks per year

Median cases per outbreak

- Pre-PulseNet: 69 cases
- Early PulseNet: 11 cases
- Listeria Initiative: 5.5 cases
- WGS: 4.5 cases

Data are preliminary and subject to change.
It’s not just tools....
Outline

• Global food safety challenges and scope of the problem
• A systems approach: appropriate tools
• **Private-public partnerships for food safety**
  – Foundation for Food and Agriculture Research (FFAR)
  – US check-off dollar-based programs
• Science-based decision making – the policy science interface
Foundation for Food and Agriculture (FFAR)

• Foundation established with $200M in government funds to invest in research and charged with leveraging those funds with equal or greater matching non-federal dollars.
  – Facilitates public-private partnerships
  – Food Safety as one potential research topic
Check-off funds

- Voluntary producer contributions
  - For example $0.15 per every 50 L of raw milk sold from a farm
  - Similar programs for beef, vegetables, fruits, and other commodities

- Funds are used to benefit sales of products, including advertising and product research, including food safety research
The mission of Cornell’s Milk Quality Improvement Program (MQIP) is to help New York State dairy producers and processors improve the quality of raw and processed milk and milk products and to ensure the safety and wholesomeness of dairy products.

The MQIP has been funded by dairy check-off dollars since 1972.
MQIP Approach

- Monitor and improve NYS raw milk quality
- Improve shelf life characteristics of commercially processed and packaged NYS milk and dairy products
- Assist NYS dairy plants in identifying and correcting handling and processing problems affecting dairy product quality
- Train professionals for the New York dairy industry (dairy certificate program)
Public-Private Partnership: Dairy food safety research supported by Dairy Check-off Funds and a US retailer (Wegmans)
Outline

• Global food safety challenges and scope of the problem
• A systems approach: appropriate tools
• Private-public partnerships for food safety
  – Foundation for Food and Agriculture Research (FFAR)
  – US check-off dollar-based programs
• Science-based decision making – the policy science interface
It’s not just science… the science-policy interface

• Food safety laws and practices need to be supported by reliable scientific information
  – Potential unintended consequences need to be considered
• Risk assessment and trade-off risk assessments are key tools for science-based risk characterization
• **Risk management (Codex definition)**: The process of weighing policy alternatives in light of risk assessment results and, if required, selecting and implementing appropriate control options, including regulatory measures.
• Universities play an important role by training people in food safety science as well as in relevant social sciences
Take home messages

• Foodborne illnesses have tremendous negative impacts on global health and potentially, on international trade
• Mitigation of food safety risks requires a systems approach, including development and use of appropriate tools by appropriately trained people who have a holistic understanding of the food system
• Innovative public-private partnerships (industry, government, academia) across the globe are needed to improve food safety