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

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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

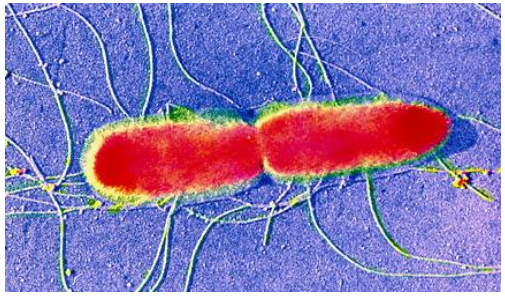
Outline

- **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

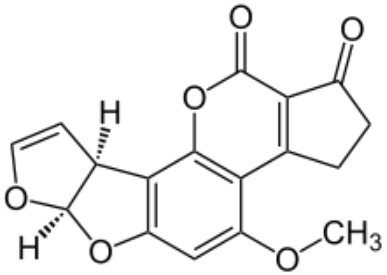
- *Giardia*
- Liver flukes
- *Toxoplasma*



Lancet 2015 385:1136-1145

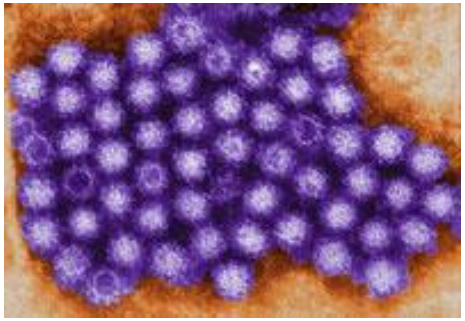
Bacteria

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



Chemicals (toxins)

- Cassava cyanide
- Aflatoxins
- Dioxins



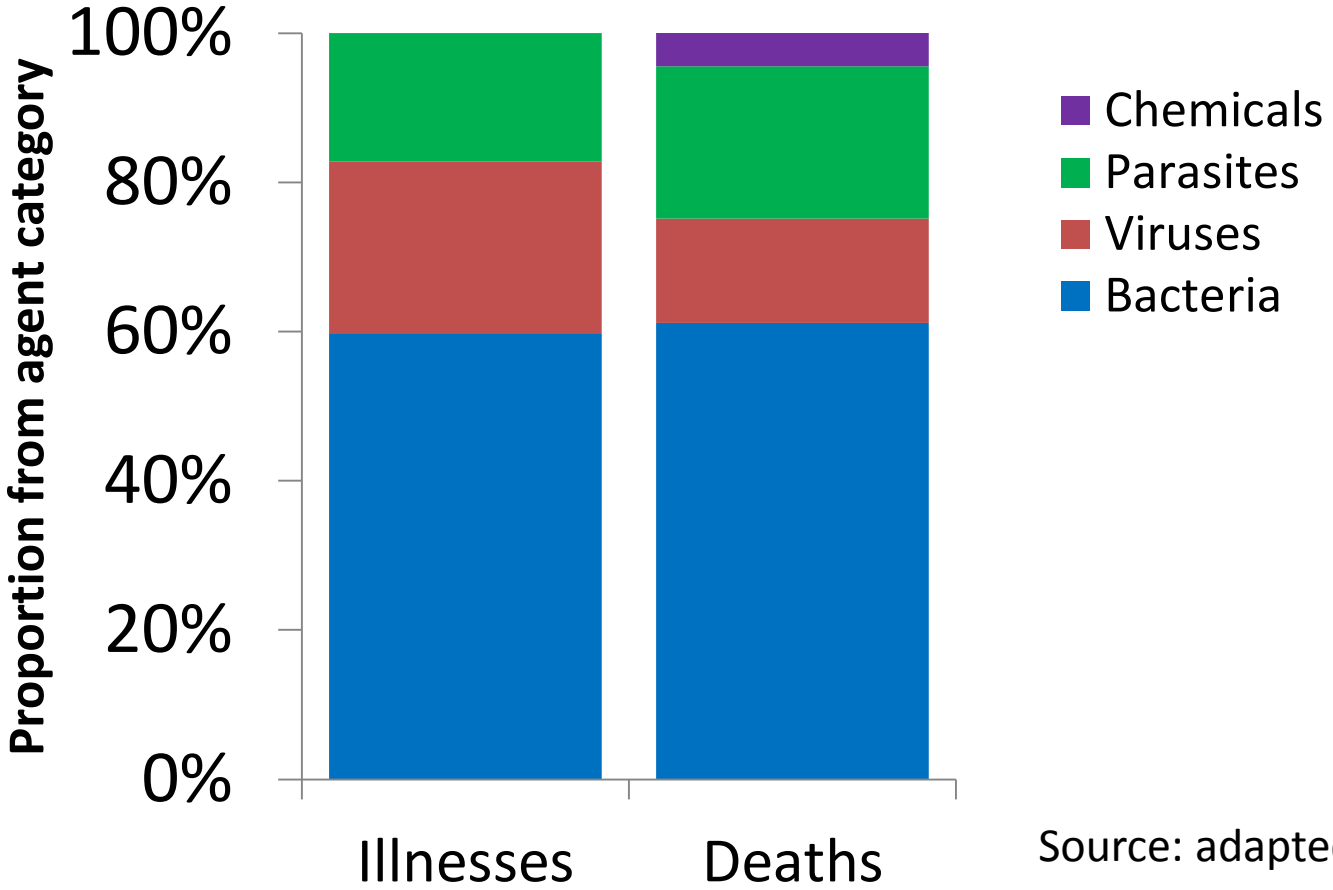
cdc.gov

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)

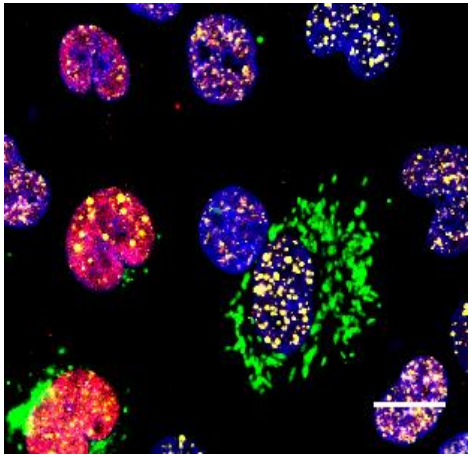


Source: adapted from WHO, 2015

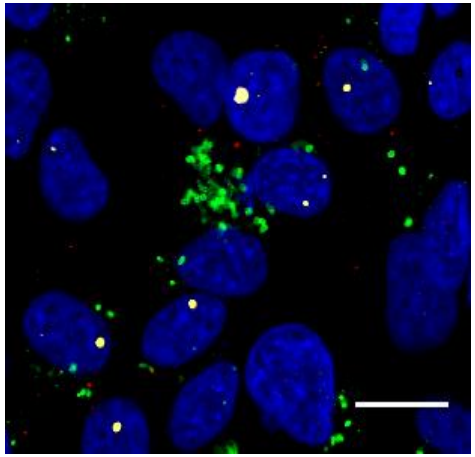
Sequelae: not just an upset stomach

- 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

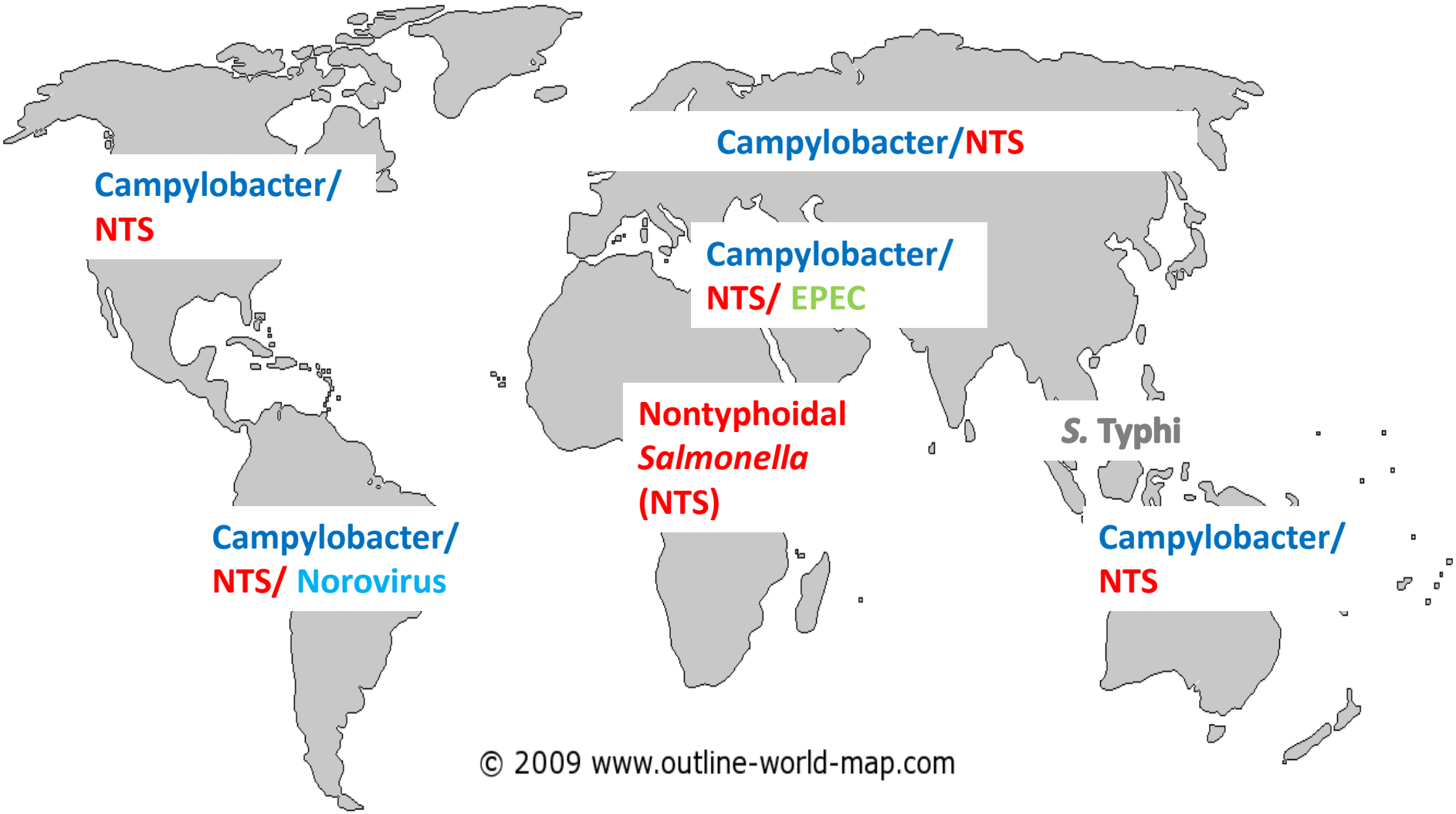


Human cells infected with Toxin (+) *Salmonella*



Human cells infected with Toxin (-) *Salmonella*

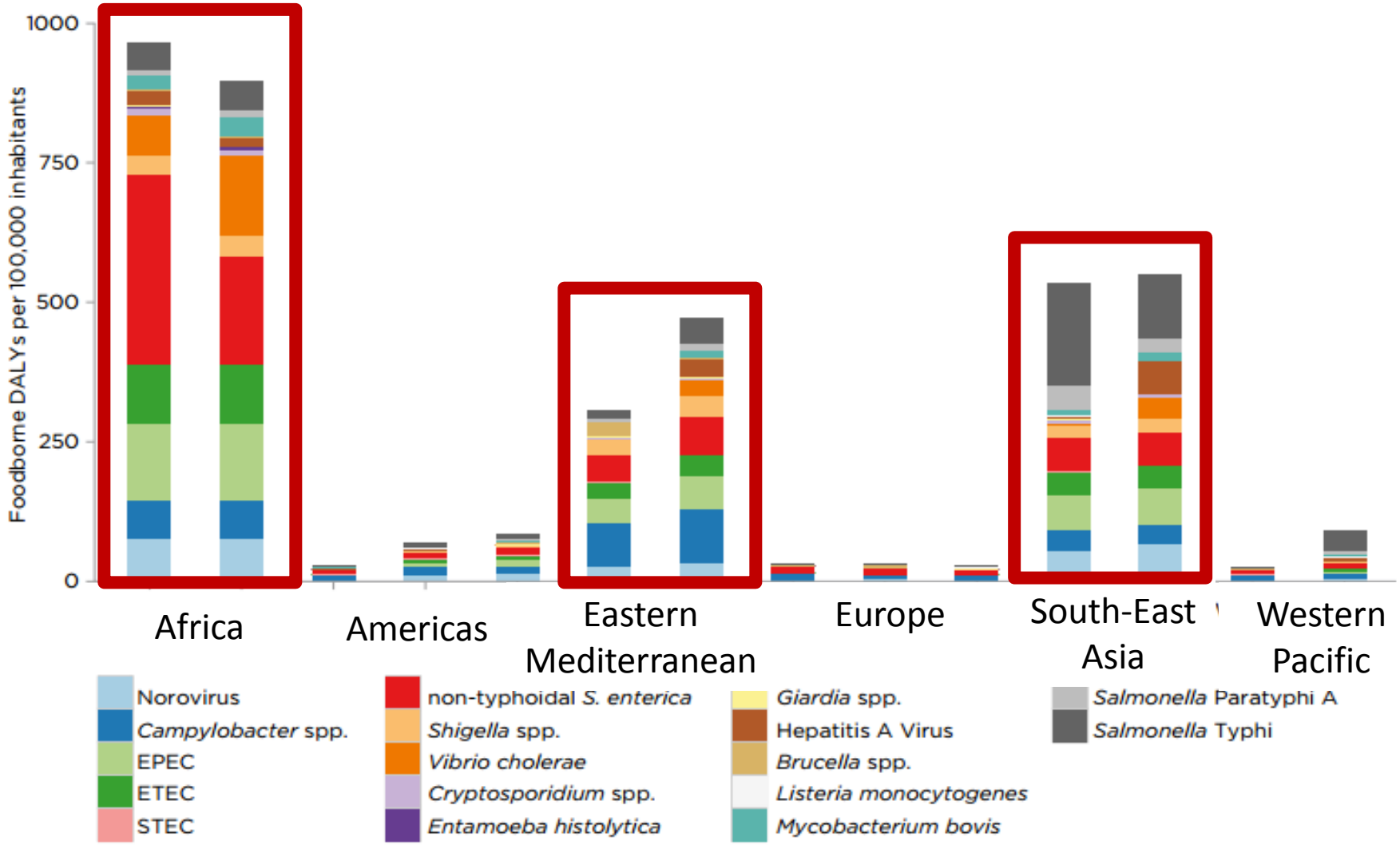
Disease burden differs by region, but NTS and *Campylobacter* are 'universal' problems



Adapted from source: WHO, 2015

Disease burden differs by geographic region

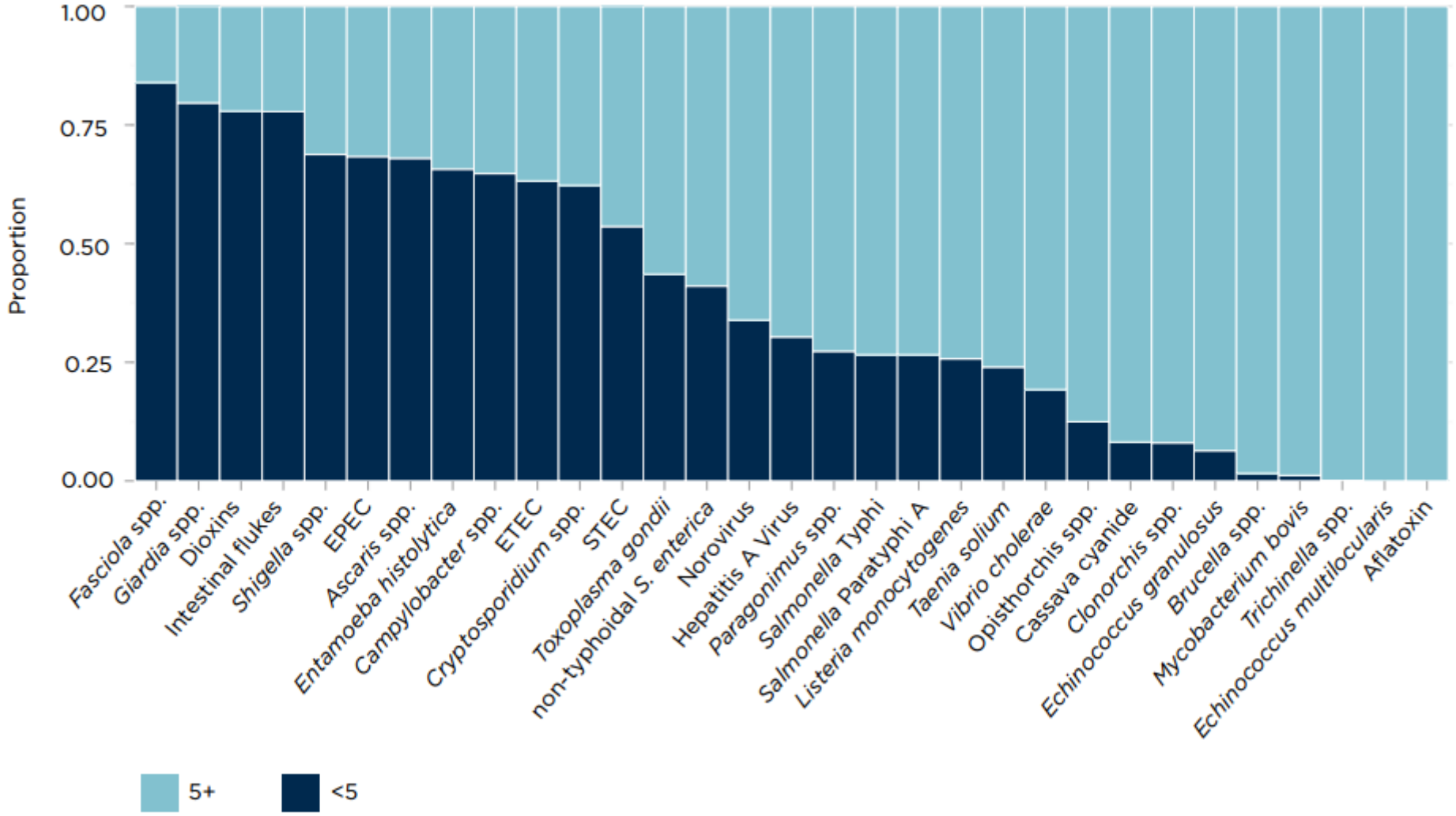
Figure 16. The global burden of foodborne disease by subregion (DALYS per 100 000 population) caused by enteric hazards, 2010.



WHO, 2015

Children <5 yrs account for ~40% of foodborne disease burden

Figure 14. Age-distribution of disability adjusted life years for 31 hazards contributing to the global burden of foodborne disease, 2010.



Economic impact of food contamination goes beyond public heath associated costs

- Recalls of contaminated foods that have not been associated with human disease cases
- Trade associated impacts

CDC > Listeria (Listeriosis) > Outbreaks

Multistate Outbreak of Listeriosis Linked to Commercially Produced, Prepackaged Caramel Apples Made from Bidart Bros. Apples (Final Update)

Posted February 12, 2015 4:30 PM ET

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

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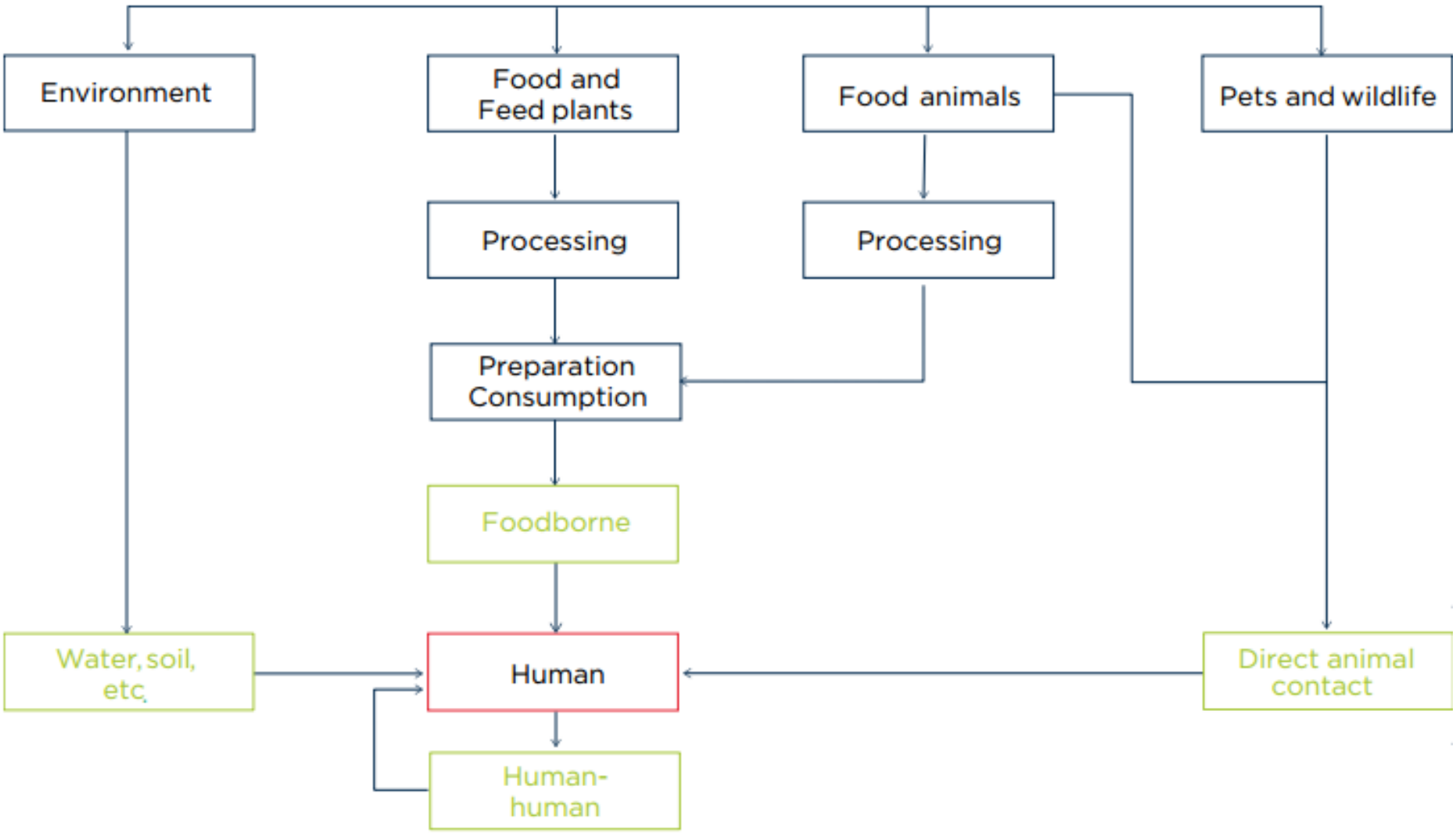
How does food become contaminated?



Source: WHO, 2015

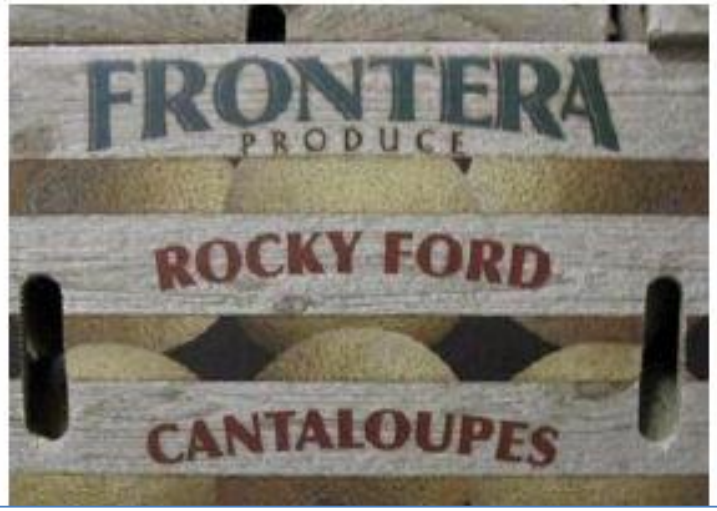
Food Safety News
Breaking news for everyone's consumption

Lawsuit Filed In Rocky Ford Cantaloupe Listeria Outbreak

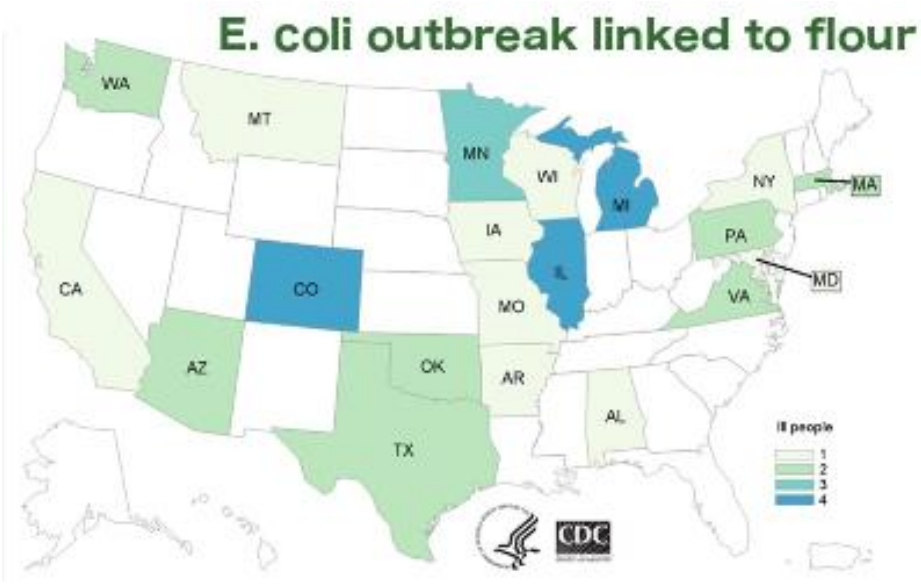
By Dan Flynn | September 16, 2011

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."



U.S. Food and Drug Administration
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Safety

Home > Safety > Recalls, Market Withdrawals, & Safety Alerts

Company Announcement

When a company announces a recall, market withdrawal, or safety alert, the FDA posts the company's announcement as a public service. FDA does not endorse either the product or the company.

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

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For Immediate Release May 2, 2016

The New York Times

BUSINESS DAY

C.D.C. Ends Chipotle Case With Illness Still a Mystery

By CHRISTINE HAUSER FEB. 1, 2016

"DNA fingerprinting"

Listeria monocytogenes
Listeria monocytogenes
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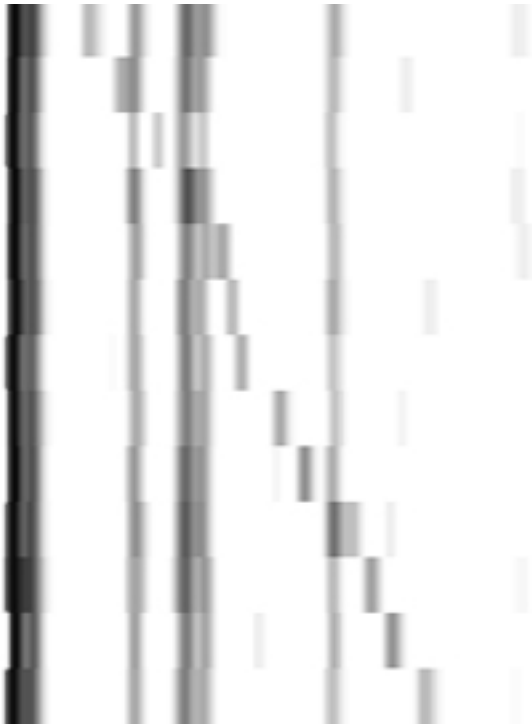
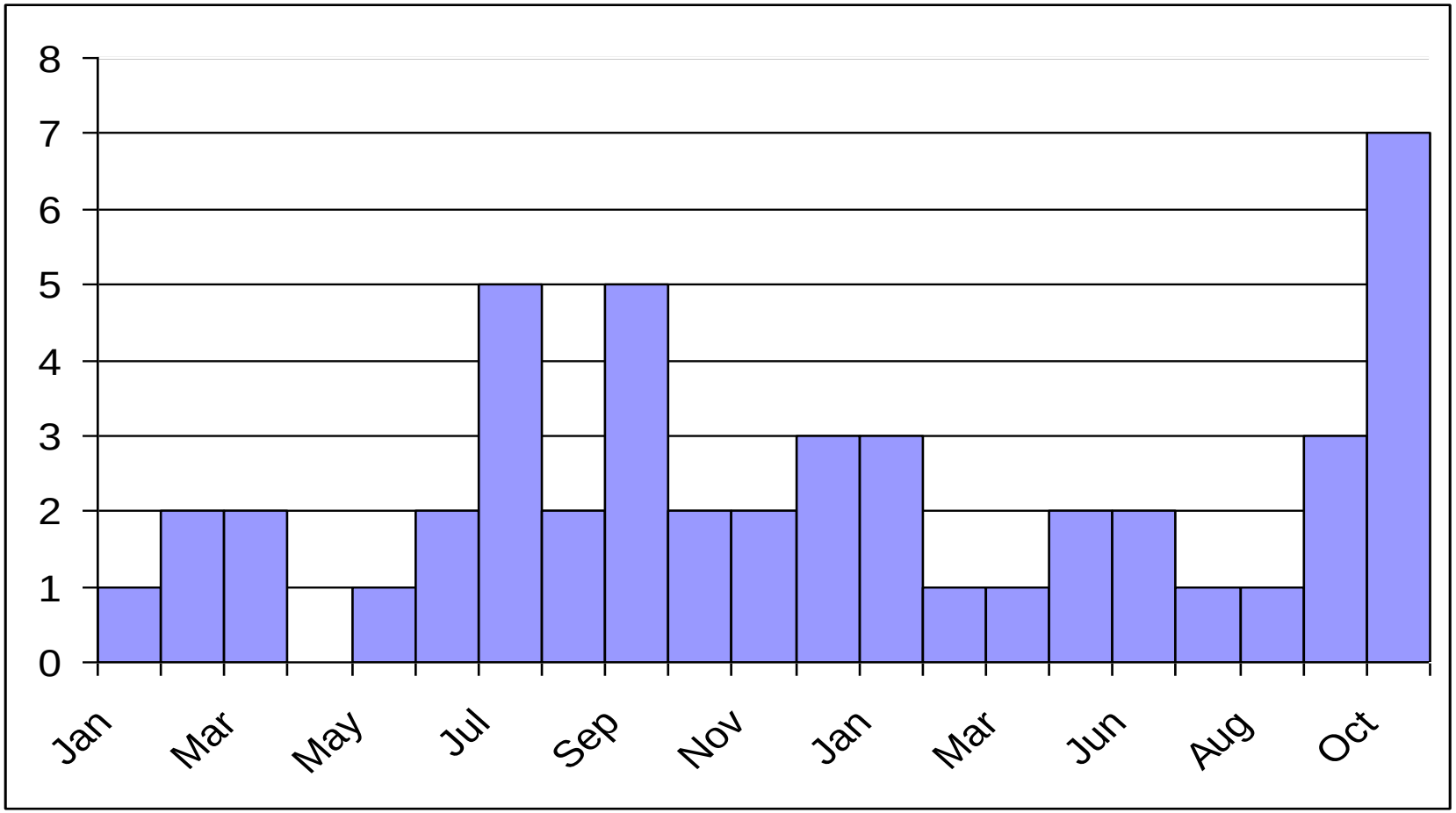


Case study – human listeriosis outbreak

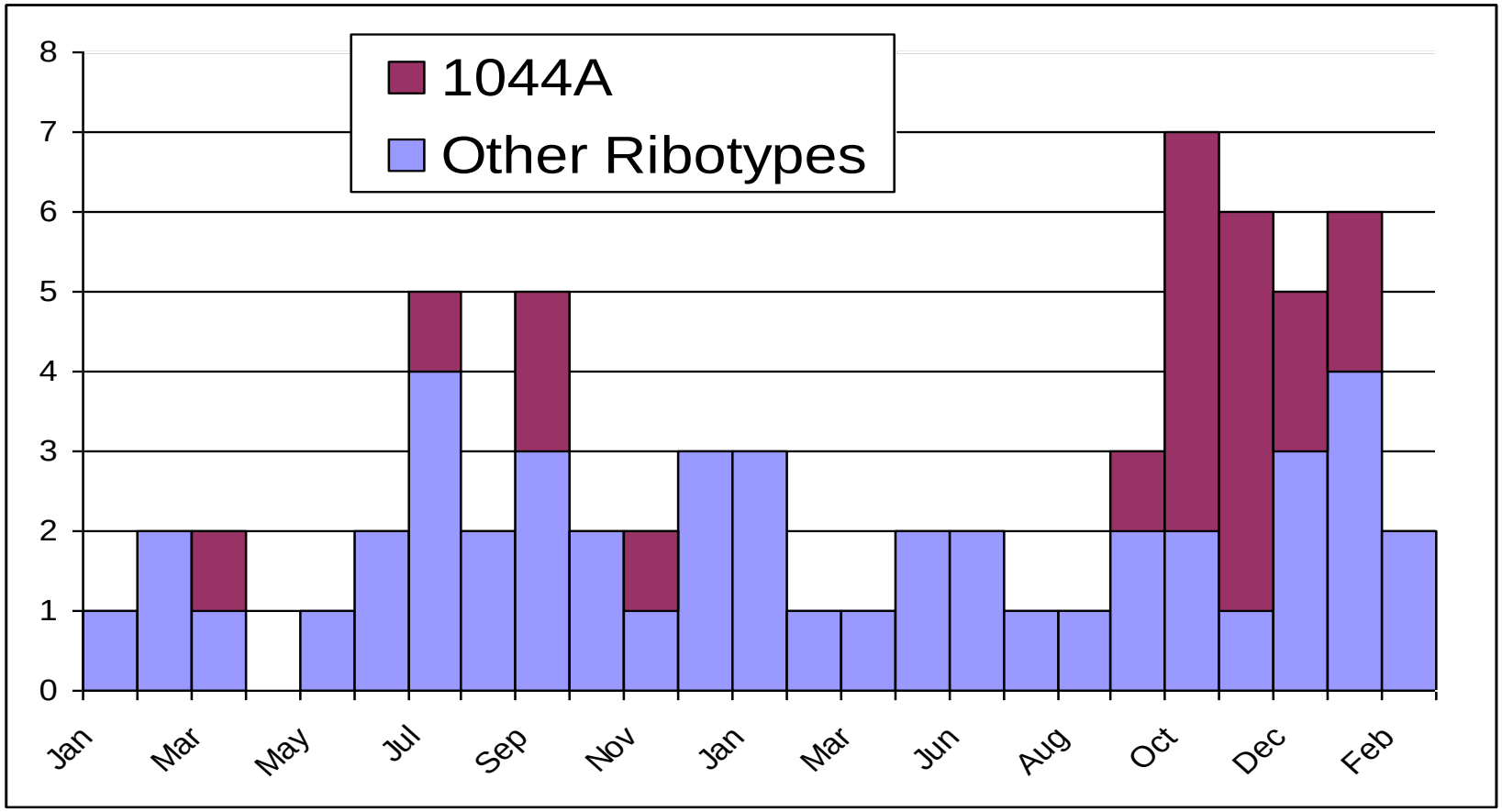
Human listeriosis cases in NYS: 1/97-10/98



Subtyping results

B98-2192	DUP-1039
B98-3297	DUP-1045
B98-3556	DUP-1042
B98-3853	DUP-1052
B98-4054	DUP-1044
B98-3412	DUP-1044
B98-4051	DUP-1044
B98-4193	DUP-1044

Epidemic curve for 1/97 - 2/99 in NYS



Epidemiol. Infect., Page 1 of 8. © 2005 Cambridge University Press
doi:10.1017/S0950268805005376 Printed in the United Kingdom

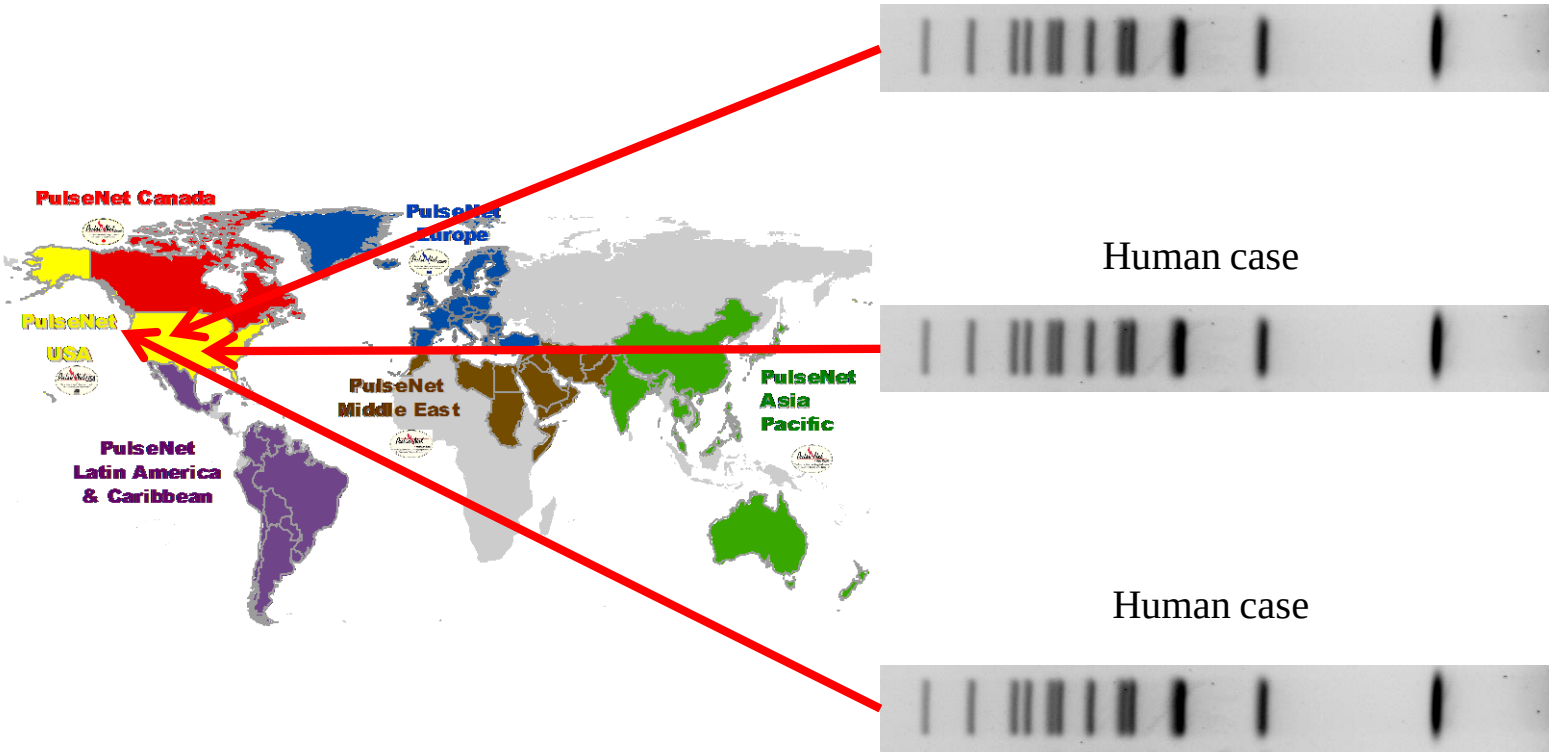
Nationwide outbreak of listeriosis due to contaminated meat

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

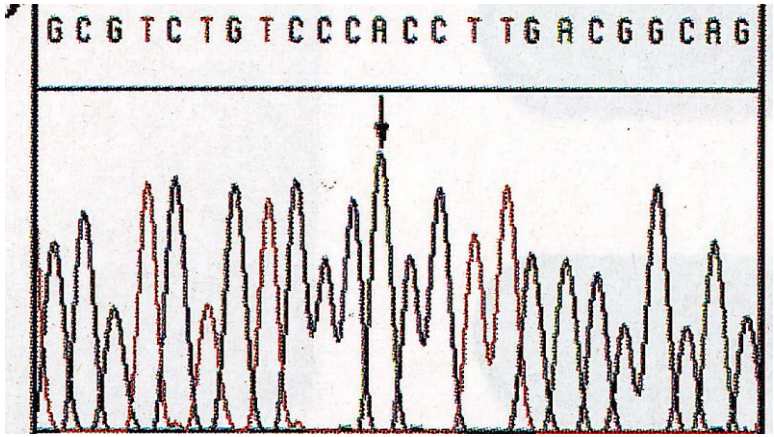
Outbreak traced back to a single specific plant in Michigan

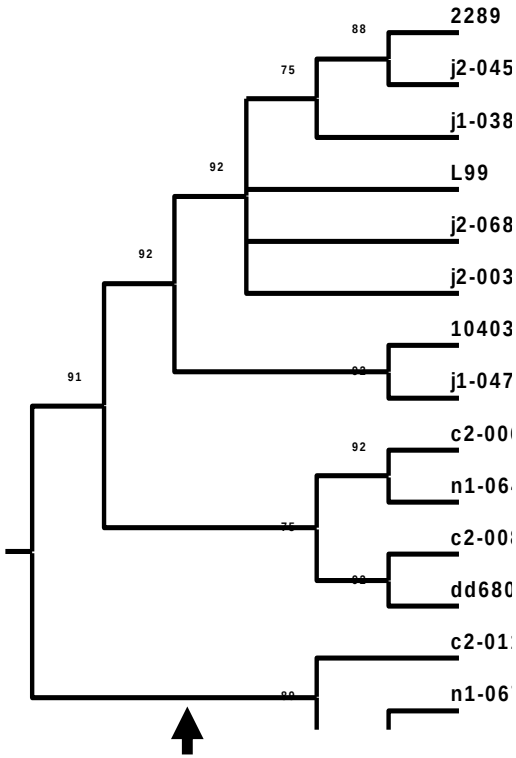
- Plant had an appropriate HACCP plan
- *L. monocytogenes* source was post-CCP contamination from the plant environment

PulseNet allows (international) outbreak detection and traceback



DNA sequencing-based subtyping





Isolate 1	AACATGCAGACTGACGATTCGACGTAGGCTAGACGTTGACTG
Isolate 2	AACATGCAGACTGACGATTCGTCGTAGGCTAGACGTTGACTG
Isolate 3	AACATGCAGACTGACGATTCGACGTAGGCTAGACGTTGACTG
Isolate 4	AACATGCATACTGACGATTCGACGAAGGCTAGACGTTGACTG

Food Safety News
Breaking news for everyone's consumption

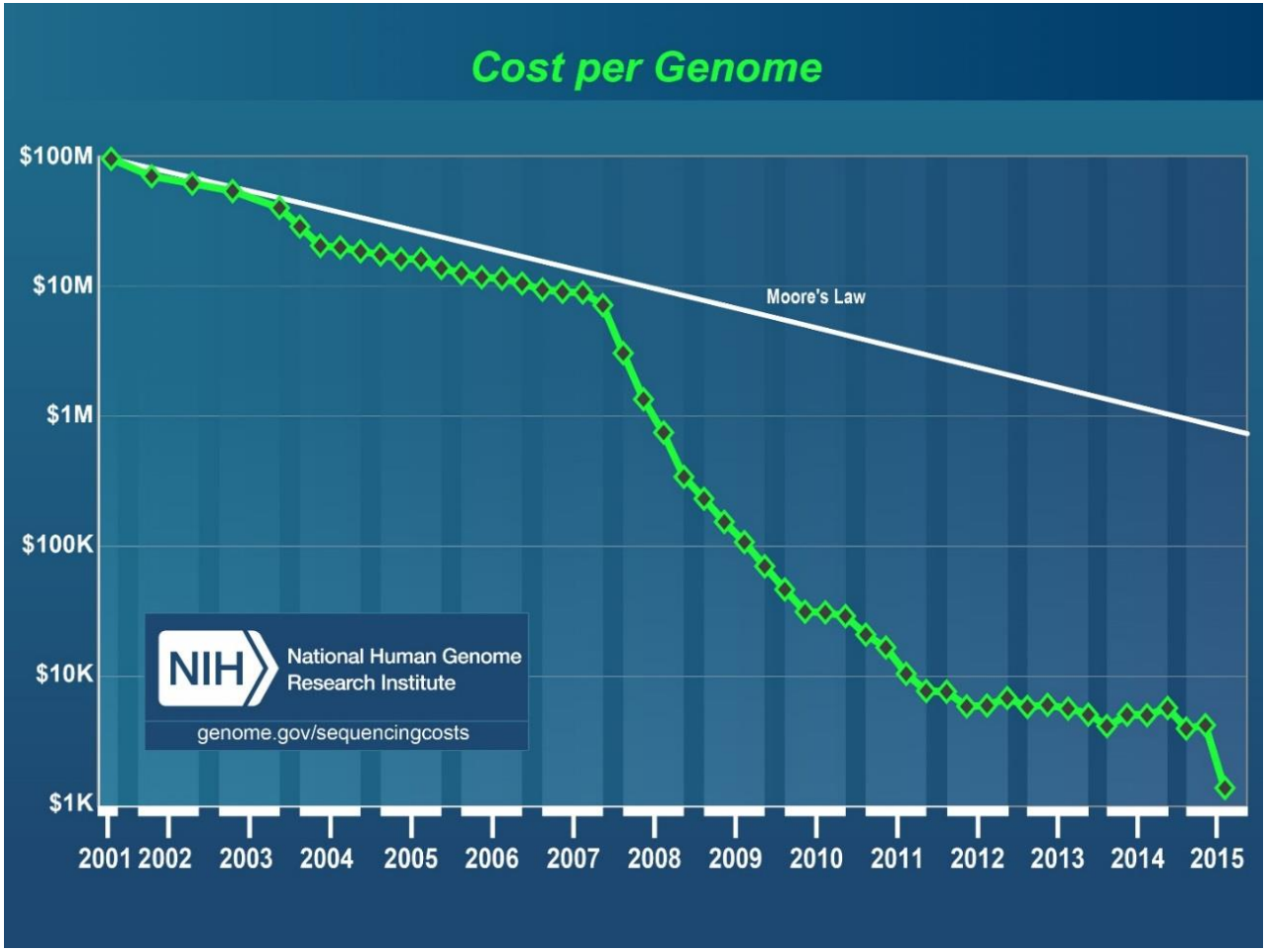
CDC/FDA Partnership Targets Whole Genome Sequencing of Listeria Monocytogenes

By Brian Sauders | 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



Multistate Outbreak of Listeriosis Linked to Soft Cheeses Distributed by Karoun Dairies, Inc.

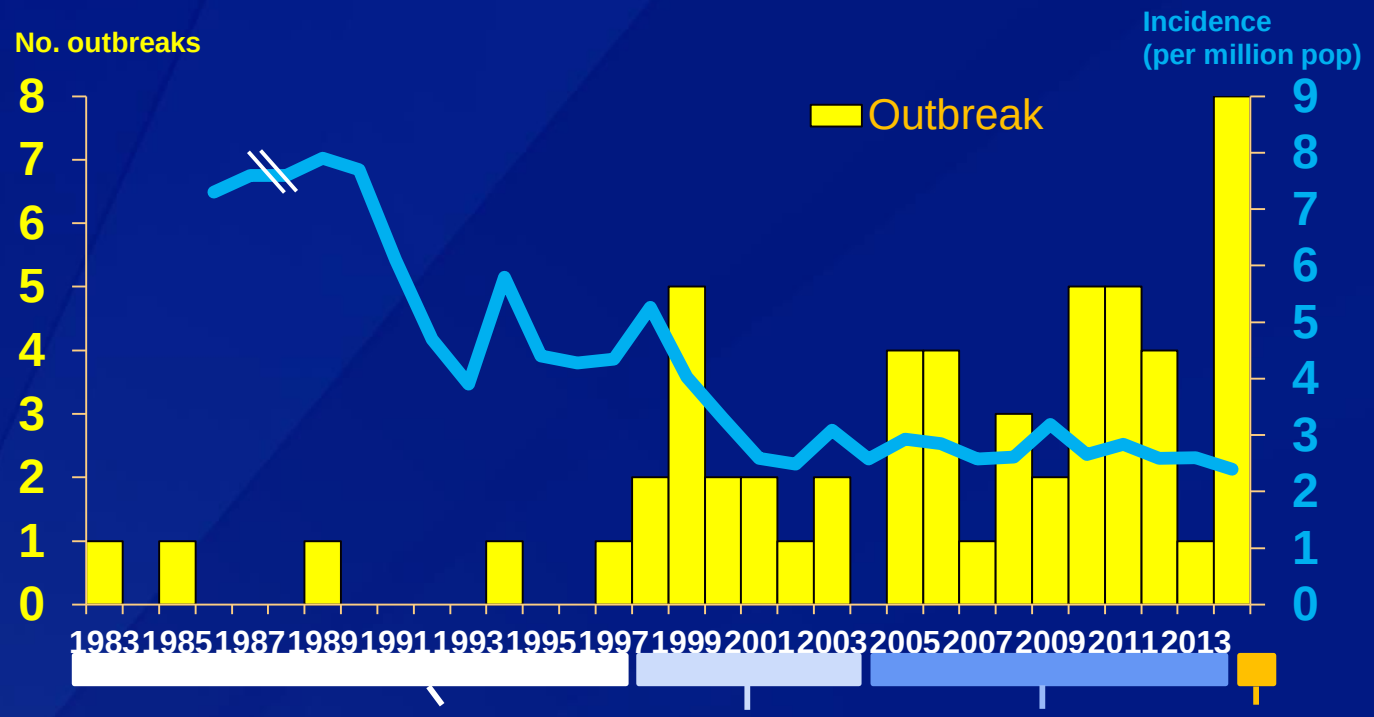
Posted September 23, 2015 3:45 PM ET

- 24 people infected with one of the closely related *Listeria* strains have been reported from 9 states since August 8, 2010.
  - 22 people were hospitalized. Five illnesses were pregnancy-related; one resulted in a fetal loss. One death was reported from Ohio.

- FDA isolated *Listeria monocytogenes* from two environmental samples collected in September 2015 from the Central Valley Cheese, Inc. manufacturing facility in Turlock, California. Central Valley Cheese, Inc. manufactures cheese for Karoun Dairies. Whole genome sequencing showed that the two isolates are closely related genetically to isolates from ill people.

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



Era	Pre-PulseNet	Early PulseNet	*Listeria* Initiative	WGS
Outbreaks per year	0.3	2.3	2.9	10
Median cases per outbreak	69	11	5.5	4.5

Data are preliminary and subject to change

It’s not just tools….

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College of Agriculture and Life Sciences

Food Safety Alumni

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  - **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

Check-off funds

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)

Journal of Food Protection, Vol. 79, No. 12, 2016, Pages 2095–2107
doi:10.4315/0362-028X.JFP-16-241

Research Paper

Development and Validation of Pathogen Environmental Monitoring Programs for Small Cheese Processing Facilities

SARAH M. BENO, MATTHEW J. STASIEWICZ,† ALEXIS D. ANDRUS, ROBERT D. RALYEA, DAVID J. KENT, NICOLE H. MARTIN, MARTIN WIEDMANN,* AND KATHRYN J. BOOR

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MS 16-241: Received 1 June 2016/Accepted 18 August 2016

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- **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

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- Innovative public-private partnerships (industry, government, academia) across the globe are needed to improve food safety