



Welcome to IFSAC's webinar:

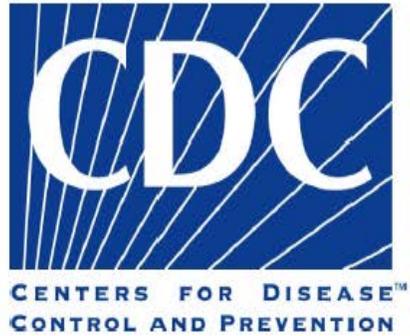
Foodborne illness source attribution estimates for 2013
for *Salmonella*, *Escherichia coli* O157,
Listeria monocytogenes, and *Campylobacter*

Please stand by – we will be starting the presentation soon.

- **Name:** Please log into the Adobe Connect software with your **first** and **last** name.
- **Audio:** We are not using Adobe Connect for audio. To listen, **please call 1-301-796-7777, passcode: 665113**
- **Q & A:** Please submit questions by typing them into the **Q & A Box**. Content questions can be submitted at any time and will be answered at the end of the presentation in the order received. We have a large number of registrants, but will attempt to answer as many questions as possible in the time allotted. Any unaddressed questions should be directed to the IFSAC email address: IFSAC@fda.hhs.gov
- **Recording:** An audiovisual recording of this webinar session will be posted online in the near future.
- **Technical Difficulties:** If you experience problems with the Adobe Connect software, please submit your technical issue in the **Q & A Box** and someone will assist you.

Today's Presenters

- **Dr. Kis Robertson Hale**, Deputy Assistant Administrator in the Office of Public Health Science (OPHS) within the Food Safety and Inspection Service (FSIS) at the United States Department of Agriculture (USDA).
- **Dr. Joanna Zablotzky Kufel**, Public Health Food Safety Analyst in the Office of Data Integration and Food Protection (ODIFP) within the Food Safety and Inspection Service (FSIS) at the United States Department of Agriculture (USDA).
- **Mr. Michael Batz**, Operations Research Analyst in the Risk Analytics Team within the Office of Resource Planning and Strategic Management (RPSM) in the Office of Food and Veterinary Medicine (OFVM) at the U.S. Food and Drug Administration (FDA).
- **Dr. LaTonia Richardson**, Statistician in the Enteric Diseases Epidemiology Branch (EDEB) within the Division of Foodborne, Waterborne, and Environmental Diseases (DFWED) in the National Center for Emerging and Zoonotic Infectious Diseases (NCEZID) at the Centers for Disease Control & Prevention (CDC).



INTERAGENCY FOOD SAFETY ANALYTICS COLLABORATION (IFSAC)

**Foodborne illness source attribution estimates
for 2013 for *Salmonella*, *Escherichia coli* O157,
Listeria monocytogenes, and *Campylobacter***

December 15, 2017

Overview of IFSAC

Dr. Kis Robertson Hale

USDA Food Safety and Inspection Service

IFSAC History

- **IFSAC was established in 2011 by:**
 - The Centers for Diseases Control and Prevention (CDC);
 - The U.S. Department of Agriculture’s Food Safety and Inspection Service (USDA-FSIS); and
 - The Food and Drug Administration (FDA).
- **Guided by a Charter written in 2011 and updated in 2016.**
- **Developed Strategic Plans for 2012-2016 and 2017-2021.**

Why IFSAC is Needed

Purpose

- **Work collectively to:**
 - Analyze and interpret human surveillance and food contamination data;
 - Share data and methods; and
 - Monitor progress toward the goal of preventing foodborne illness.

Goals

- **Identify, plan, and conduct selected food safety and foodborne illness analytic projects recognized as high priority by all three agencies.**
 - Foodborne illness source attribution (the proportion of foodborne illnesses that can be attributed to specific foods) is the current focus of IFSAC's activities.
- **Improve coordination of federal food safety analytic efforts.**
- **Address cross-cutting priorities for food safety data collection, analysis, and use.**

How IFSAC Works

Interagency collaboration that:

- Builds on a history of working together on source attribution.
- Applies advances in source attribution methods.
- Leverages knowledge, expertise, and data among agencies.
- Drives an efficient structure guided by strategy.
- Prioritizes communications and stakeholder input.

Shared Structure and Strategy

Steering Committee (SC)

- Senior members from each Agency able to commit resources.
- Annual rotation of chairperson among agencies.
- Assesses, approves and oversees IFSAC projects.

Technical Workgroup (TWG)

- Designated group of Agency experts and analysts.
- Develops proposals and executes plans for IFSAC projects.
- Coordinates IFSAC activities within each Agency.

Communications Workgroup (CWG)

- Develops communication materials (conference materials, webinars, press releases, etc.).
- Coordinates with Agency communications specialists to ensure harmonization of materials and messaging.
- Develops harmonized responses to media or other external inquires.

Project Teams

- Assigned Agency experts performing specific projects.

Outreach and Information Sharing

Established IFSAC website

- <https://www.cdc.gov/foodsafety/ifsac/index.html>

Publications, Manuscripts, and Reports

- IFSAC. 2015. Foodborne illness source attribution estimates for Salmonella, E. coli O157, Listeria monocytogenes, and Campylobacter using outbreak surveillance data: Report.
- Comparing Characteristics of Sporadic and Outbreak-Associated Foodborne Illnesses, United States, 2004–2011. [Emerging Infectious Diseases](#). July 2016.
- An Updated Scheme for Categorizing Foods Implicated in Foodborne Disease Outbreaks: A Tri-Agency Collaboration. [Foodborne Pathogens and Disease](#). December 2017.
- Working Title: Statistical Modeling to Attribute Foodborne Illnesses Caused by Four Pathogens to Food Sources. In development.

Invited Presentations

- UGA Industry Safe Foods Forum
- National Restaurant Association Panel
- Poultry Health, Processing, and Live Production Meeting

Outreach and Information Sharing, Continued

Scientific Presentations

- Society for Risk Assessment (SRA)
- Council for State and Territorial Epidemiologists (CSTE)
- International Association of Food Protection (IAFP)
- Association of Food and Drug Officials (AFDO)

Media Appearances

- Emerging Infectious Diseases Journal Podcast (2016)
- Food Chemical News (2017)

Public Meetings

- 2012, 2015

Webinars

- 2013: Improving the Categories Used to Classify Foods Implicated in Outbreaks
- 2014: Are Outbreak Illnesses Representative of Sporadic Illnesses?
- 2017: Strategic Plan and Future Directions

Introduction

Dr. Joanna Zablotzky Kufel

USDA Food Safety and Inspection Service

Approaches to Foodborne Illness Source Attribution

- **Analysis of aggregated outbreak data**
- **Sporadic epidemiological studies**
 - Case-control, case-case, case exposure ascertainment
- **Pathogen subtype matching models**
- **Quantitative microbial risk assessment**
- **Structured expert elicitation**

Outbreak-based Source Attribution

- **A foodborne outbreak occurs when two or more people get the same illness from the same contaminated food or drink.**
- **Outbreak data is useful for attribution studies because it explicitly links illnesses to identified food vehicles.**
- **Data are collected at the national level and are available over time.**
- **Outbreak-based source attribution presumes that food sources of outbreaks are similar to those of sporadic disease.**

IFSAC Estimates for 2012

- **We developed a robust and novel approach for estimating foodborne illness source attribution for *Salmonella*, *E. coli* O157, *Listeria monocytogenes*, and *Campylobacter* based on 15 years (1998-2012) of FDOSS outbreak data. This approach:**
 - Used a food categorization scheme aligned with regulatory needs;
 - Addressed biases and adjusted for outbreak size;
 - Down-weighted the influence of older data; and
 - Used Bayesian bootstrapping to calculate uncertainty around estimates
- **In 2015, IFSAC published these estimates:**
 - Presented at a [public meeting](#)
 - [Short Report](#) published on IFSAC webpage
 - Media coverage
 - Developing manuscript on this method

Developing Estimates for 2013

- **Building on this approach, IFSAC developed a framework to publicly provide regularly updated, harmonized attribution estimates.**
- **Today, IFSAC is providing updated estimates for 2013 using the same data source and modeling approach, with some modifications.**

Methods

Michael Batz

U.S. Food and Drug Administration

Our Overall Approach

- **Follows the approach we used in estimates for 2012, published in 2015.**
- **U.S. foodborne outbreaks with single pathogen & single food vehicle, 1998-2013.**
- **Most outbreak-based efforts calculate proportions of outbreak events or outbreak-associated illnesses that can be attributed to a food category.**
- **Rather than use reported illnesses, we use statistical modeling to mitigate the influence of outliers and incorporate epidemiological factors into estimates.**
- **We also give greater weight in the estimates to more recent outbreaks, which is different than previous efforts.**
- **We then use model-estimated illnesses as the basis for attribution calculations.**
- **Manuscript is in development, so the methods may evolve based on peer review, and we may incorporate further enhancements in the future.**

U.S. Outbreak Data

- **Public health agencies in states and localities have primary responsibility for identifying and investigating outbreaks and use a standard form to report outbreaks to CDC.**
- **Electronic reporting started in 1998, now done through the National Outbreak Reporting System (NORS).**
- **Foodborne outbreak reports are collected in FDOSS and include data on:**
 - Date of first illness
 - Location (state or states)
 - Causal pathogen(s)
 - Food vehicle(s) implicated
 - Number of reported and laboratory-confirmed illnesses
 - Additional contributing factors

Data Decisions

Three key assumptions about which data to include in the analysis

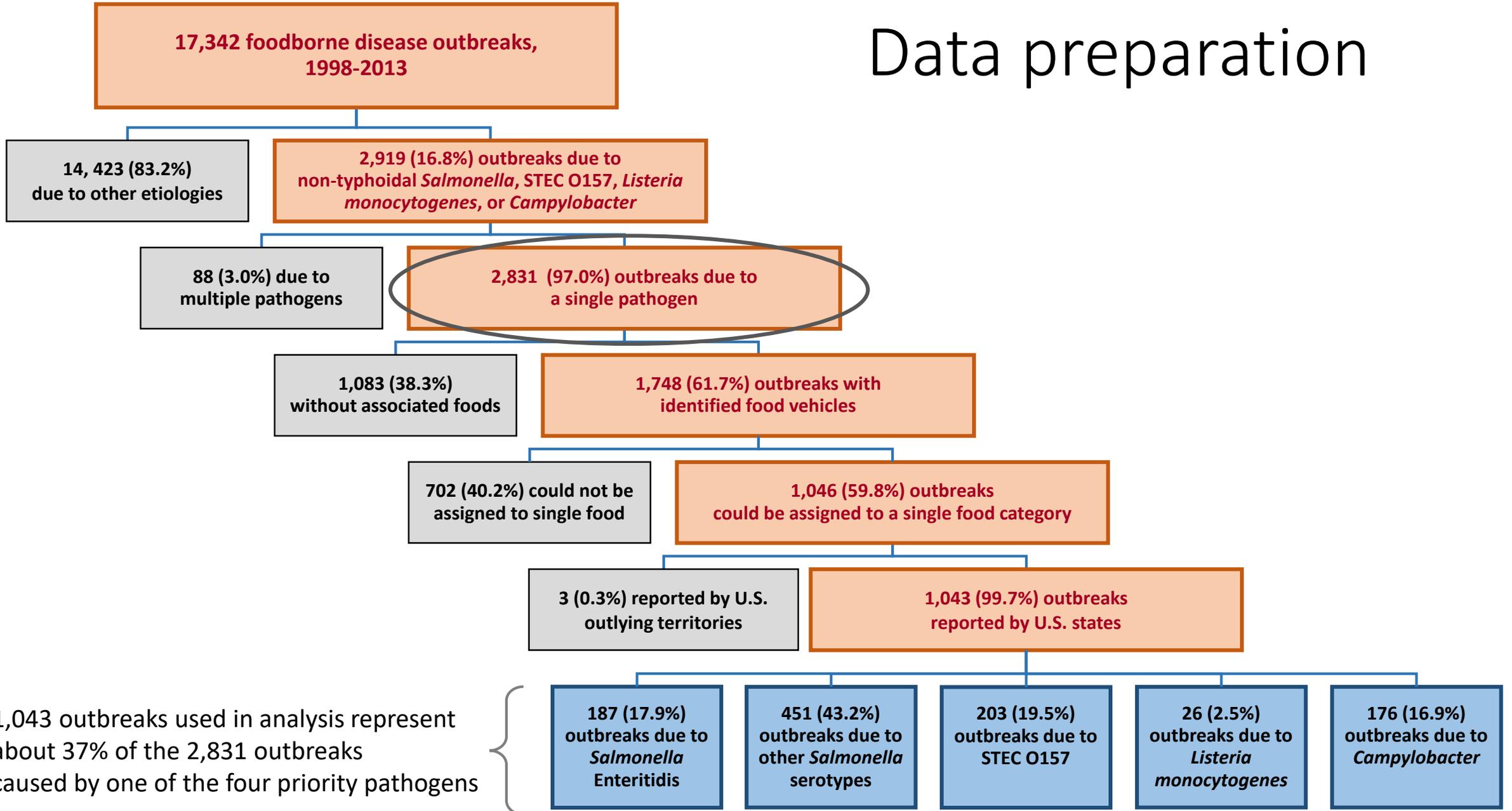
1. Include outbreaks with suspected and confirmed etiology (causal pathogen)

- “Confirmed” means the pathogen has been confirmed by laboratory analysis of isolates from multiple patients or from an epidemiologically implicated food.
- 90% of outbreaks have confirmed pathogen; of those without confirmed pathogen, 95% have one lab-confirmed illness.
- No significant differences found between outbreaks with confirmed and suspected pathogen.
- Including outbreaks with suspected pathogens does not change estimates, but does tighten credibility intervals.

2. Include outbreaks with suspected and confirmed implicated foods

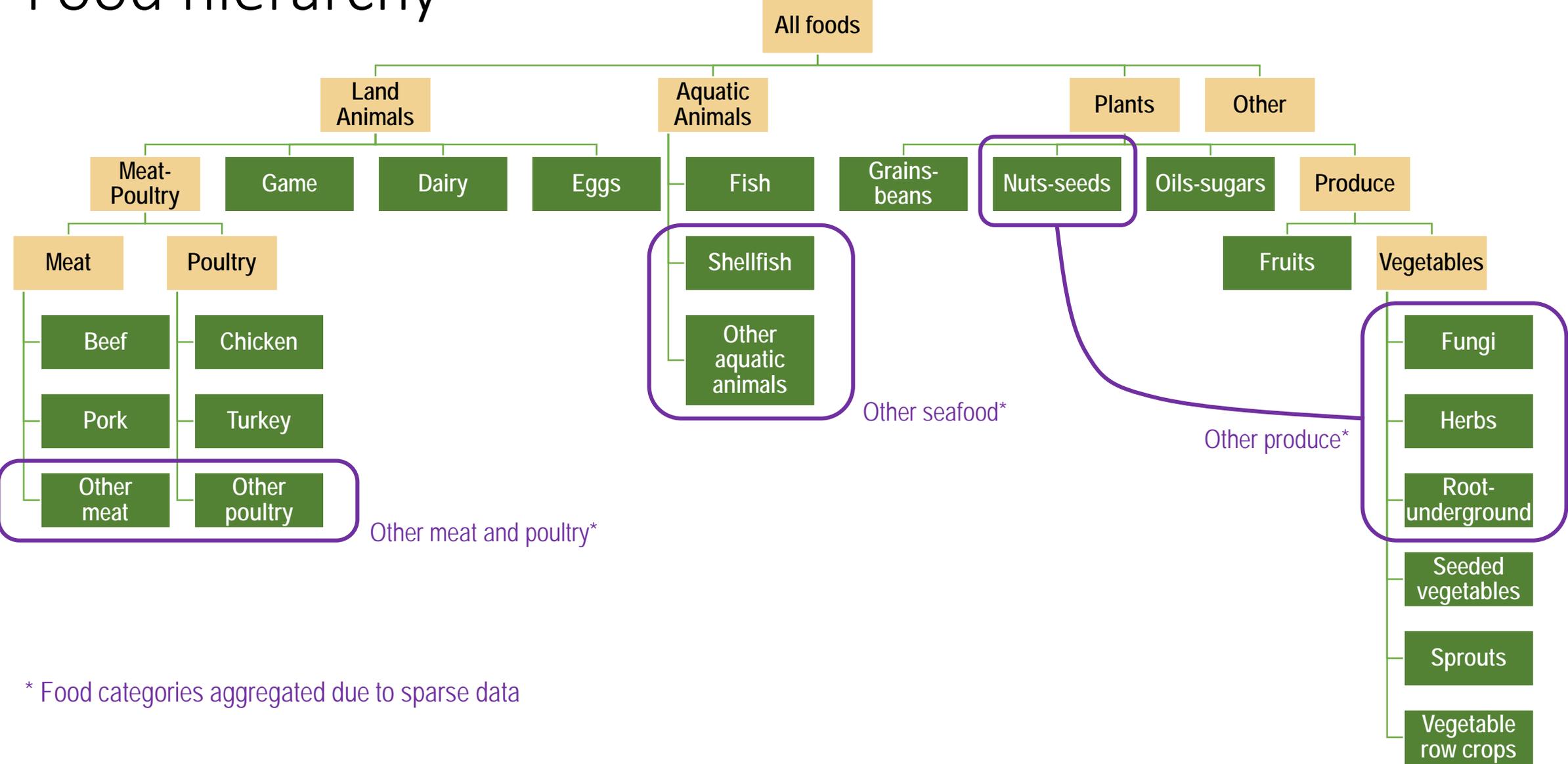
3. Include all reported outbreak illnesses, not only those that were laboratory-confirmed

Data preparation



1,043 outbreaks used in analysis represent about 37% of the 2,831 outbreaks caused by one of the four priority pathogens

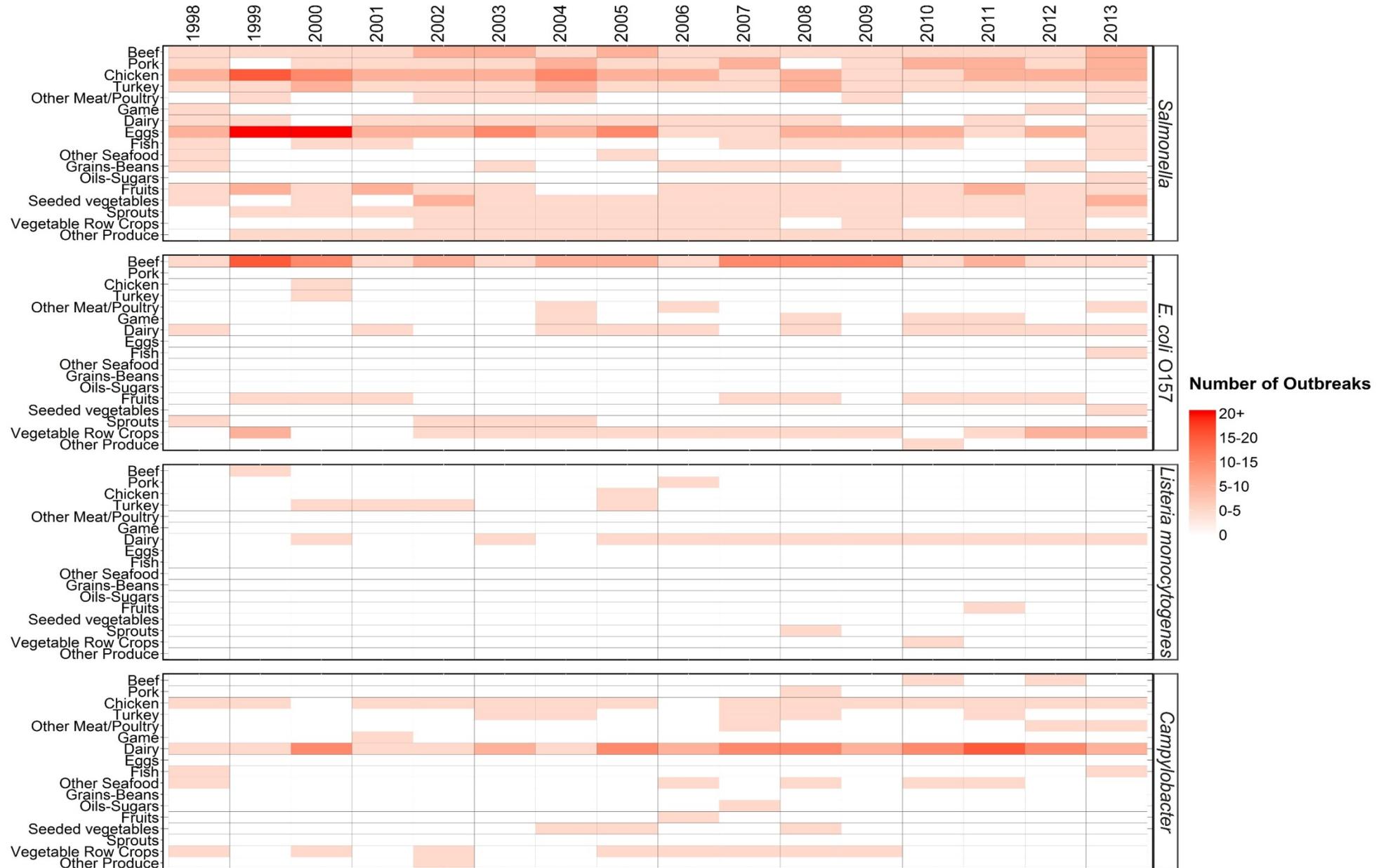
Food hierarchy



* Food categories aggregated due to sparse data

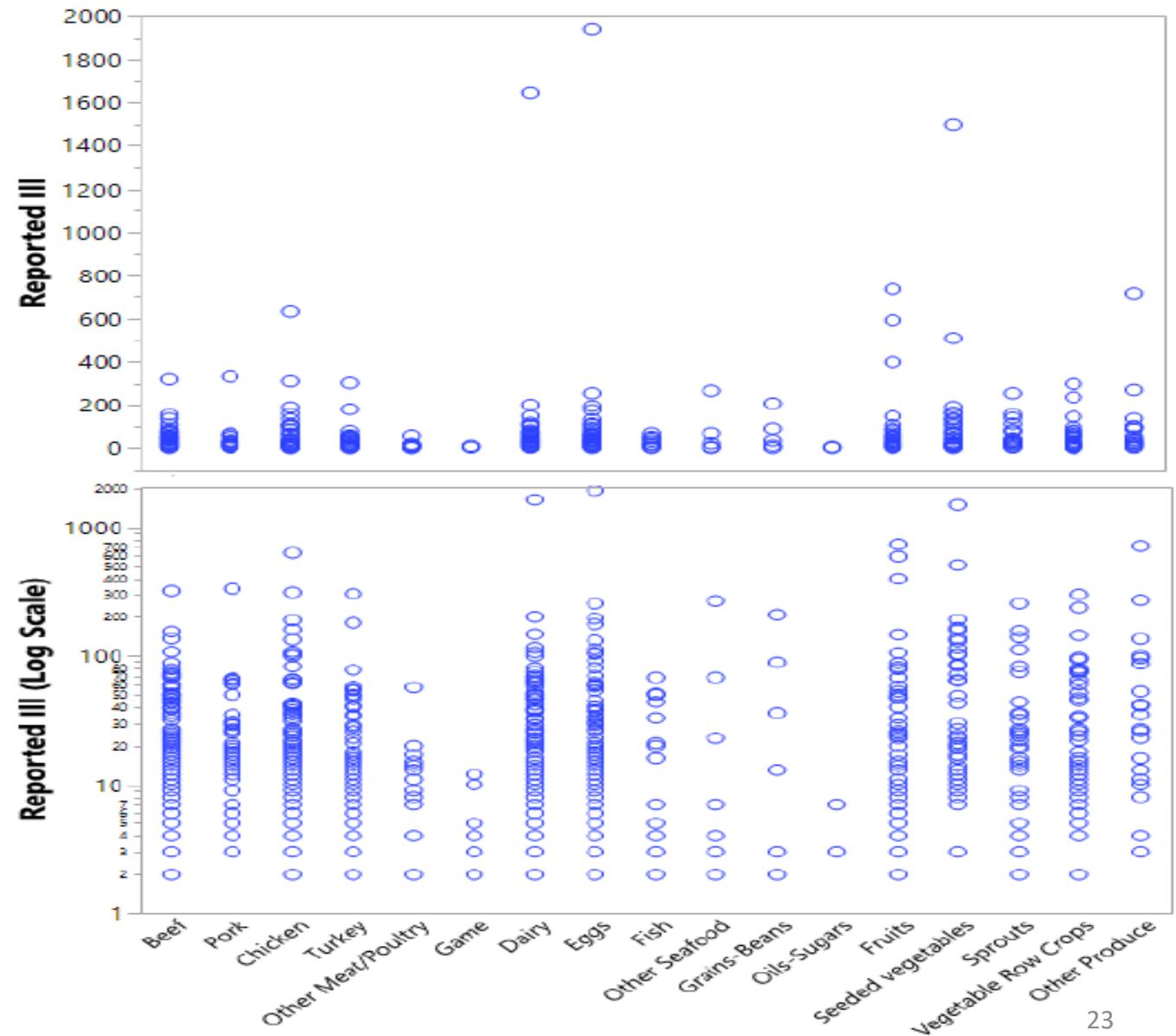
For more on the IFSAC food categorization scheme, see Richardson *et al.* 2017 <https://doi.org/10.1089/fpd.2017.2324>

Number of reported outbreaks by pathogen, food category, and year



Variance in Outbreak Size

- **Highly variable outbreak size (2 to 1,939 illnesses per outbreak).**
- **Highly skewed – many small outbreaks, a few huge ones.**
- **Log-transformation normalizes the distribution of outbreak size.**

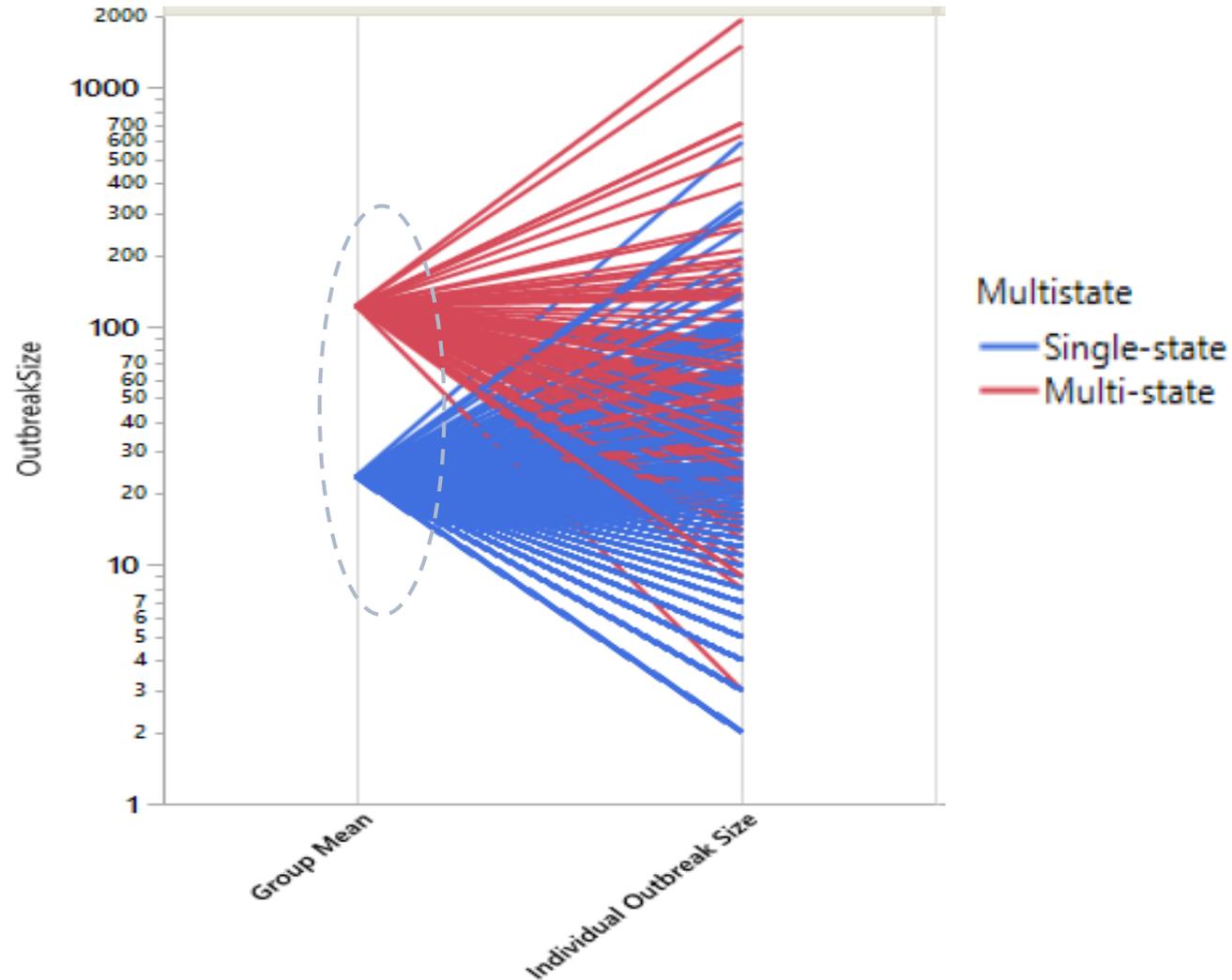


Epidemiological Factors

- **Implicated foods**
 - 17 food categories
- **Geographical information**
 - Multi-state: exposures occurred in multiple states
 - Single-state: exposures occurred in a single state
- **Location of food preparation**
 - Private homes
 - Restaurants
 - Other (e.g. banquet, hospital, school, prison)
 - Multiple locations
 - Unknown

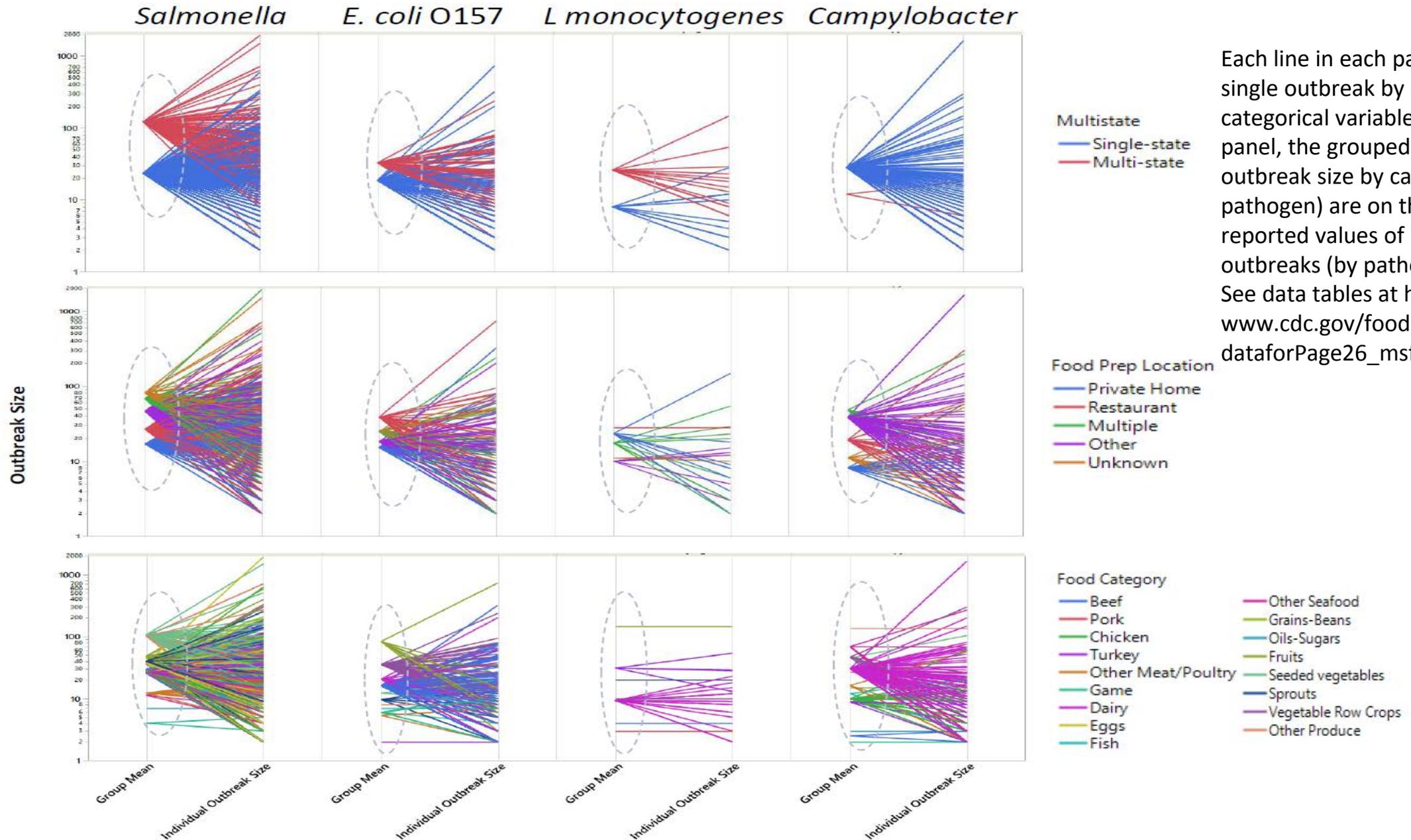
Variation in Outbreak Size Across Epidemiological Factors

Salmonella



Each line in each panel represents a single outbreak by pathogen and categorical variable. Within each panel, the grouped means of outbreak size by category (for that pathogen) are on the left, with reported values of individual outbreaks (by pathogen) to the right. See date tables at https://www.cdc.gov/foodsafety/ifsac/files/dataforPage25_msfoodprep_v2.xlsx

Variation in Outbreak Size Across Epidemiological Factors



Each line in each panel represents a single outbreak by pathogen and categorical variable. Within each panel, the grouped means of outbreak size by category (for that pathogen) are on the left, with reported values of individual outbreaks (by pathogen) to the right. See data tables at https://www.cdc.gov/foodsafety/ifsac/files/dataforPage26_msfoodprep_v2.xlsx

Modelling Outbreak Illnesses

- **For each pathogen, an analysis of variance (ANOVA) model of the log-transformed number of illnesses has the form:**

$$\text{Log ill} = \alpha + \beta_1(\text{Multi-state}) + \beta_2(\text{Prep location}) + \beta_3(\text{Food category})$$

where

- Multi-state: whether an outbreak occurred in a single state or multiple states
 - Prep location: Type of food preparation location (restaurant, private home, etc.)
 - Food category: one of 17 food categories
- **Log ill are back-transformed ($e^{\text{Log ill}}$) to obtain model-estimated illnesses.**
 - **Each outbreak was thus assigned a model-estimated number of illnesses. For example:**
 - All **single-state (β_1)** *Campylobacter* outbreaks in which food was prepared **in a restaurant (β_2)** and the implicated food was **Chicken (β_3)** were assigned the same model-estimated number of illnesses.

Down-weighting Older Outbreaks

- Outbreaks from most recent 5 years given full weight.
- Outbreaks from each earlier year given exponentially lower weight.
- Weighting factor w for year y is given by:

$$w_y = \begin{cases} a^{(Y-5)-y}, & y < Y - 5 \\ 1, & y \geq Y - 5 \end{cases}$$

where Y is 2013 (the final year of data)

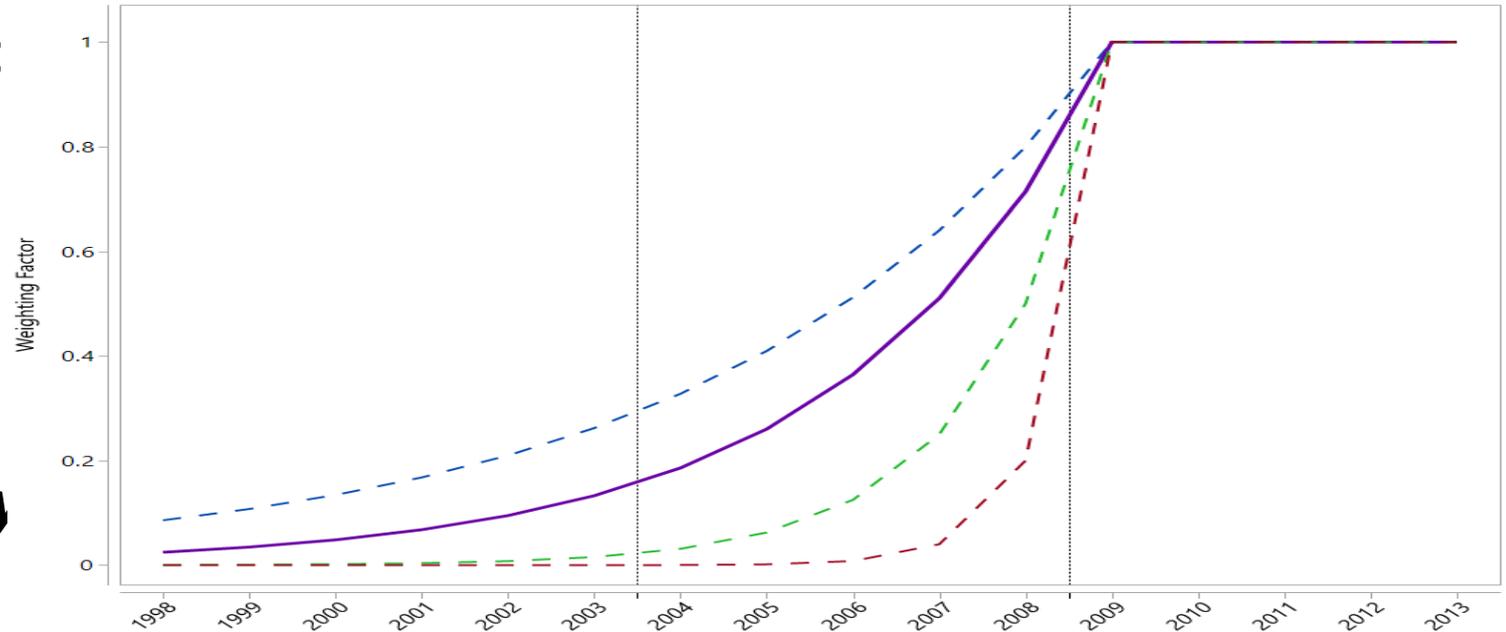


Figure Legend	Proportion of total information by time period		
	1998 - 2003	2004 - 2008	2009 - 2013
Exponential Factor (a)		Years of Data	
--- 8/10 (0.8)	11%	2004 - 2008	58%
--- 5/7 (0.71)	5%	2004 - 2008	67%
--- 1/2 (0.5)	<1%	2004 - 2008	83%
--- 1/5 (0.2)	0%	2004 - 2008	95%

Attribution Percentages & Uncertainty

- **For a given pathogen, we calculate the attribution percentage for a specific food category as the weighted sum (only the early years are down-weighted) of model-estimated illnesses for that food category divided by the total weighted sum of model-estimated illnesses over all food categories.**
 - For example, of the total 6,159 (down-weighted, model-estimated) outbreak illnesses due to *Salmonella*, 1,022 of these illnesses were associated with Seeded Vegetables; therefore, we attribute 16.6% ($1,022/6,159$) of foodborne *Salmonella* illnesses to Seeded Vegetables.
- **We account for uncertainty in the estimates by forming 90% credible intervals around the estimates using Bayesian bootstrap resampling.**

Excluding *Campylobacter*/Dairy

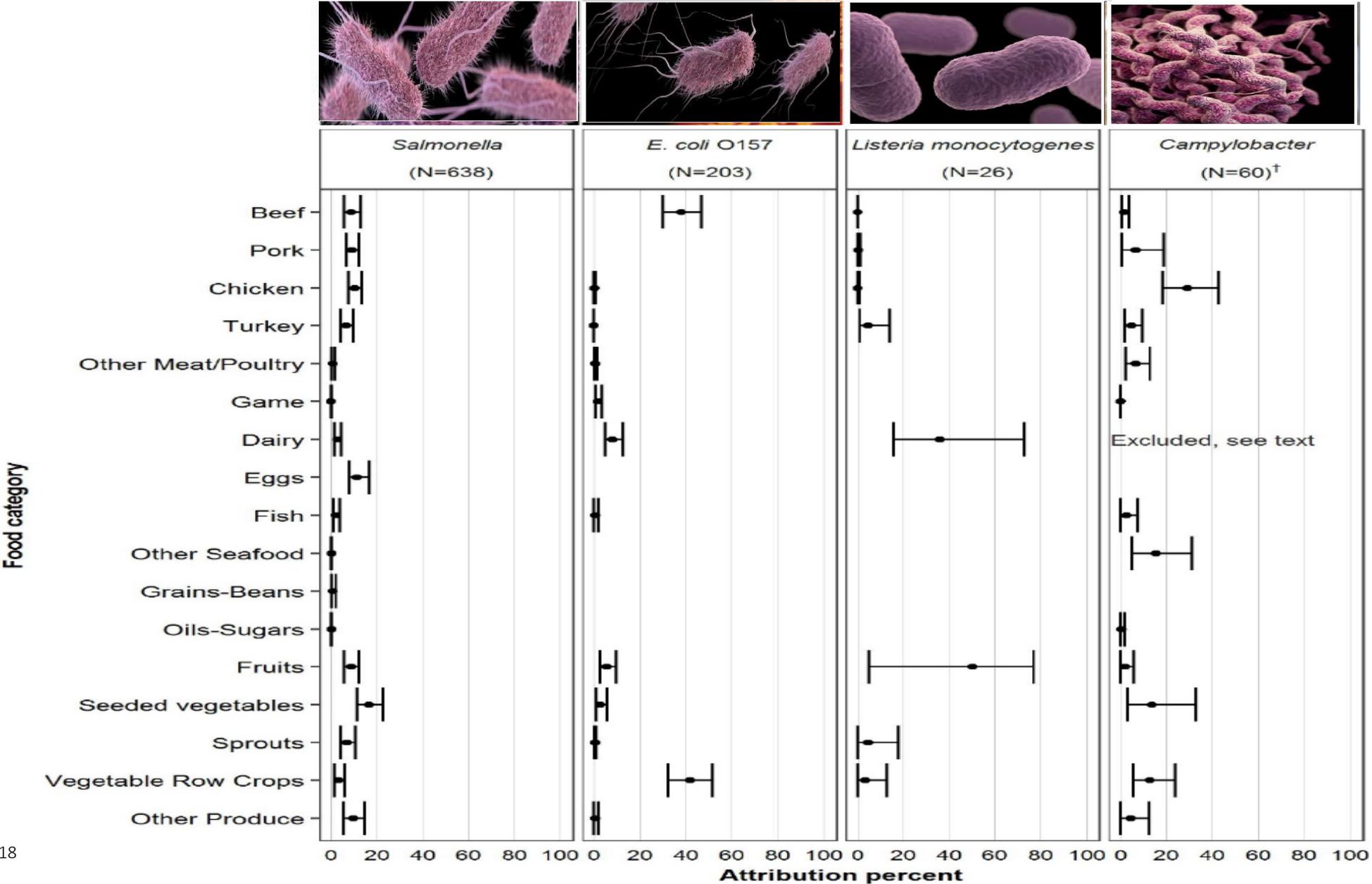
- **We exclude outbreaks associated with the Dairy category from attribution percentage calculations for *Campylobacter*:**
 - The majority of *Campylobacter* outbreaks were associated with unpasteurized milk, but raw milk is a high-risk product not widely consumed by the general population.
 - Thus, these outbreaks likely over-represent Dairy as a source of overall (e.g. non-outbreak) *Campylobacter* illness.
 - Epidemiological studies of sporadic campylobacteriosis assign very low attribution percentages to dairy products and identify chicken as the most significant food vehicle.
 - Structured expert elicitations also quantify the attribution percentage to dairy products overall to be quite low.
- **We, therefore, estimated attribution percentages for non-Dairy food categories.**
- **Removing Dairy outbreaks resulted in *Campylobacter* attribution percentages more consistent with the published literature.**

Results

Dr. LaTonia Richardson

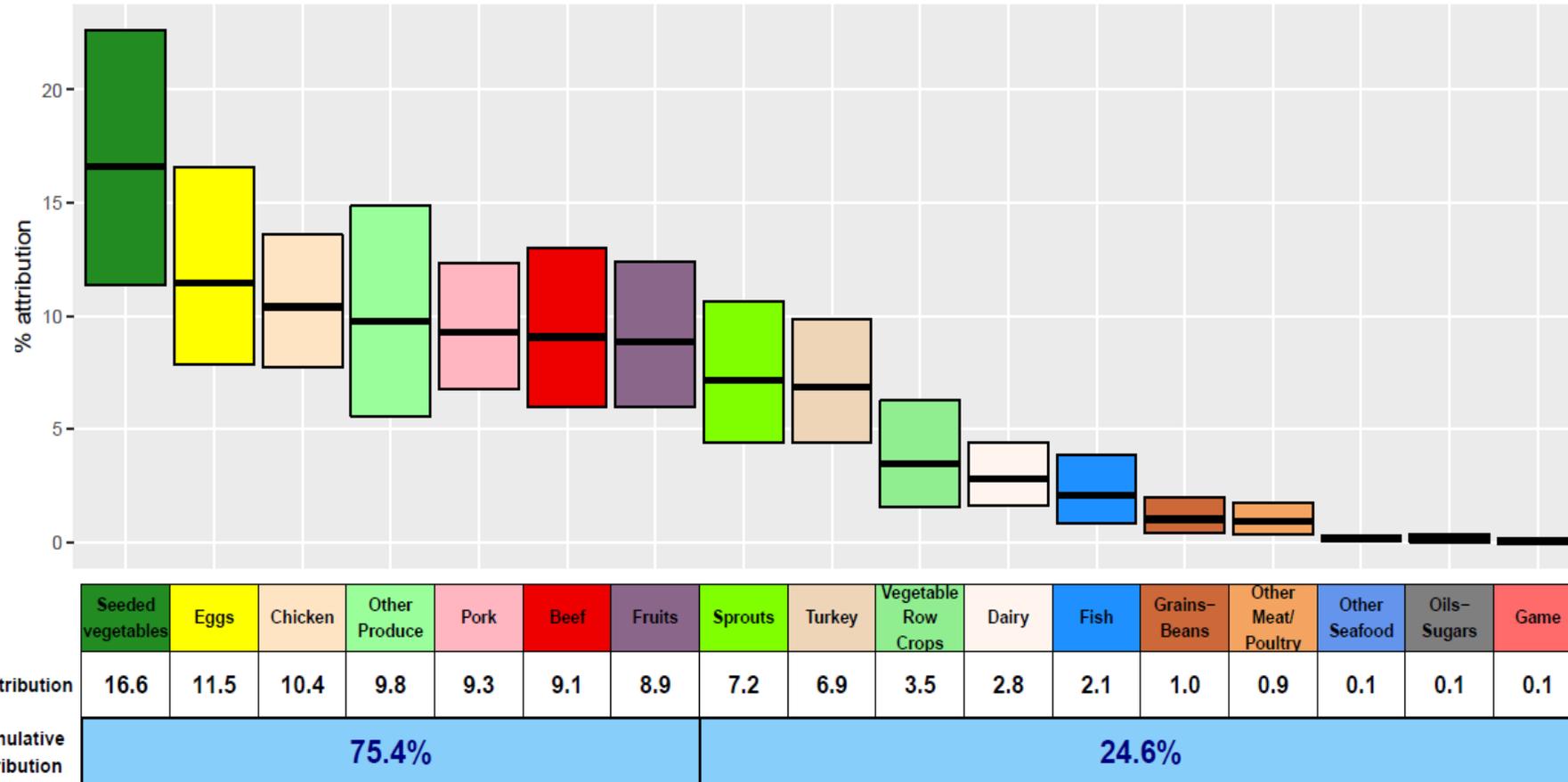
U.S. Centers for Disease Control and Prevention

Foodborne Illness Source Attribution Estimates for 2013



Salmonella

Source Attribution Estimates and 90% Credibility Intervals

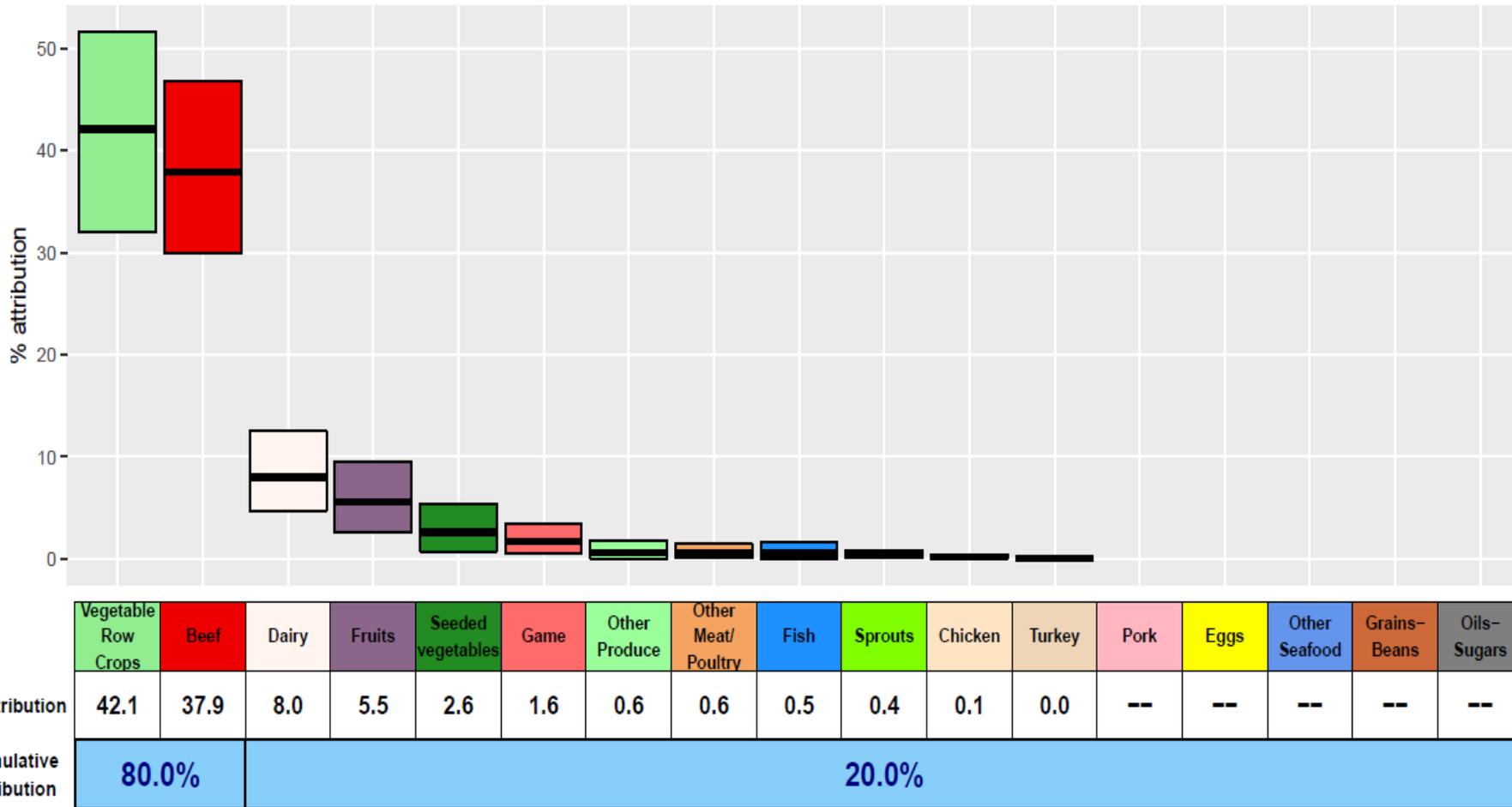


- Over 75% of illnesses attributed to seven food categories.
- No statistically significant differences in the estimated attribution among most food categories.

Based on a model using multi-year outbreak data that gives equal weight to each of the most recent five years of data (2009 – 2013) and exponentially less weight to each earlier year (1998–2008).

E. coli O157

Source Attribution Estimates and 90% Credibility Intervals

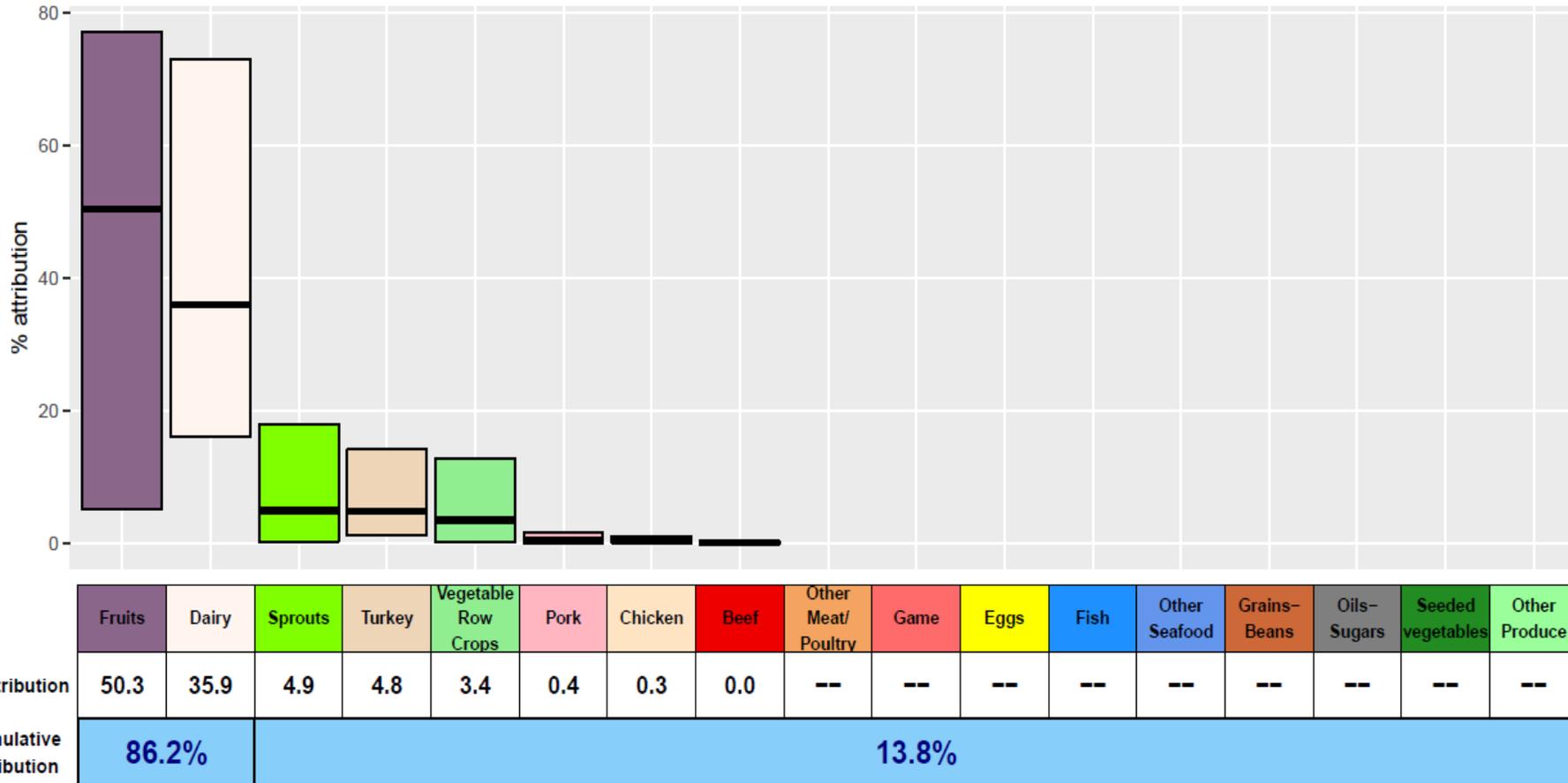


- **80% of illnesses attributed to Vegetable Row Crops and Beef.**
- **Credibility intervals for Beef and Vegetable Row Crops categories overlap; no statistically significant difference between their estimated attribution percentages.**
- **No illnesses attributed to Pork, Eggs, Other Seafood, Grains-Beans, or Oils-Sugars.**

Based on a model using multi-year outbreak data that gives equal weight to each of the most recent five years of data (2009 – 2013) and exponentially less weight to each earlier year (1998–2008).

Listeria monocytogenes

Source Attribution Estimates and 90% Credibility Intervals

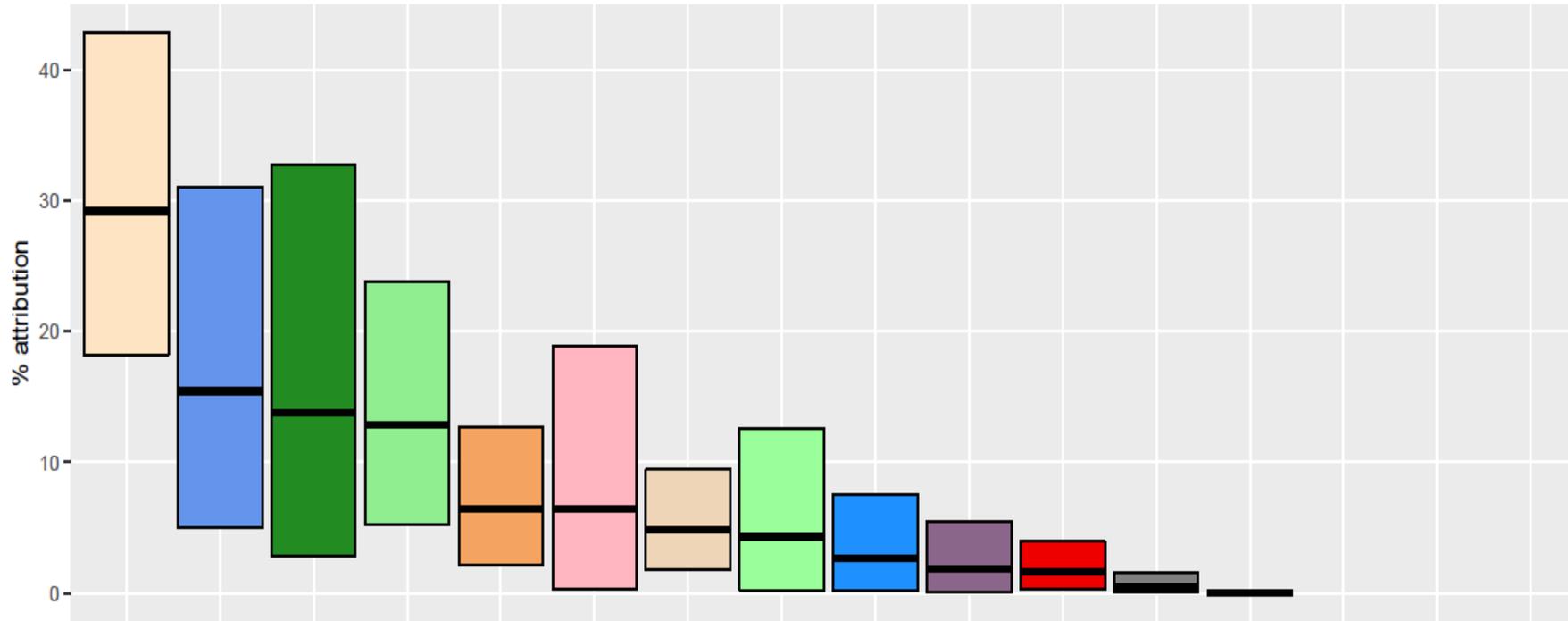


- Nearly 90% of illnesses attributed to Fruits and Dairy.
- Credibility intervals for Fruits and Dairy categories were wide and overlapped.
- No illnesses attributed to Other Meat/Poultry, Game, Eggs, Fish, Other Seafood, Grains-Beans, Oils-Sugars, Seeded Vegetables, or Other Produce.

Based on a model using multi-year outbreak data that gives equal weight to each of the most recent five years of data (2009 – 2013) and exponentially less weight to each earlier year (1998–2008).

Campylobacter

Source Attribution Estimates and 90% Credibility Intervals



	Chicken	Other Seafood	Seeded vegetables	Vegetable Row Crops	Other Meat/Poultry	Pork	Turkey	Other Produce	Fish	Fruits	Beef	Oils-Sugars	Game	Eggs	Grains-Beans	Sprouts
% attribution†	29.2	15.4	13.8	12.9	6.5	6.5	4.9	4.3	2.6	1.8	1.6	0.5	0.0	--	--	--
cumulative attribution†	77.7%						22.3%									

- Almost 80% of non-Dairy illnesses attributed to five food categories.
- No statistically significant differences in the estimated attribution were found among most food categories.
- Attribution percentage for Dairy not presented because most foodborne *Campylobacter* outbreaks were associated with unpasteurized milk, which is not widely consumed.

† *Campylobacter* estimates exclude results derived from Dairy outbreak data

Discussion

Key Findings

- **Illnesses from *Salmonella* and *Campylobacter* are broadly attributed across multiple food categories, which suggests that interventions designed to reduce illnesses from these pathogens need to target a variety of food categories.**
- **In contrast, *E. coli* O157 and *Listeria monocytogenes* illnesses were attributed to fewer food categories, which suggests more targeted interventions.**
- **The occurrence of outbreaks due to novel pathogen-food category pairs, such as an *E. coli* O157 outbreak due to soy nut butter in 2017, mandates vigilance in seeking unrecognized food sources of outbreaks and illnesses.**

Campylobacter Results

- **The attribution percentage for Dairy is not presented in the *Campylobacter* figure for several reasons:**
 - Most *Campylobacter* outbreaks included in the database were associated with unpasteurized milk, which is not widely consumed by the general population, and
 - *Campylobacter* outbreaks in the Dairy food category (which accounted for 68% of the total *Campylobacter* attribution) appear to over-represent Dairy as a source of *Campylobacter* illness.
- **After removing the Dairy outbreaks, the Chicken attribution increased from 9% to 29%, which is consistent with published literature.**

Evaluating our Methods

- **We compared results based on model-estimated illnesses to those based on reported illnesses.**
- **We conducted a number of sensitivity analyses around model assumptions and data:**
 - Down-weighting older data;
 - Alternative ANOVA model specifications;
 - Sensitivity to outliers; and
 - Etiology status (confirmed/suspected).
- **We found our estimates robust to outliers, with a single exception:**
 - A single large outbreak linked to cantaloupes in 2011 had a major influence on the *Listeria monocytogenes* attribution estimates.

Limitations

- **Outbreaks account for a small proportion of overall foodborne illnesses.**
 - Jones *et al.* 2004 <https://doi.org/10.1086/381599>
- **Many outbreaks don't implicate a single food.**
- **For pathogens with a small number of outbreaks, very large outbreaks can have substantial influence on the attribution point estimate.**
- **This analysis only included 36% of reported outbreaks caused by the four priority pathogens, which may not be representative of all outbreaks from these pathogens.**
- **Nearly 10% of illnesses in our analysis occurred among institutionalized populations, such as those in prisons, hospitals, and schools; these populations allow easier identification of cases, allow for more complete data collection, have fewer food options, and are not representative of the general population.**

Conclusions

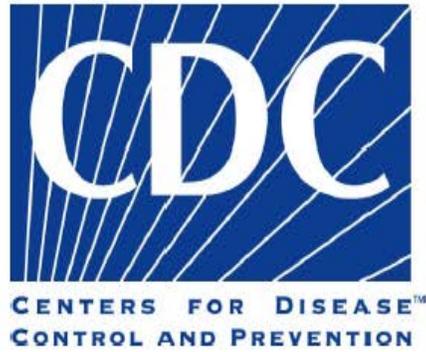
- **Our approach addresses a number of issues with outbreak-based foodborne illness source attribution:**
 - Used a food categorization scheme aligned with regulatory needs;
 - Addressed biases and adjusted for outbreak size;
 - Down-weighted the influence of older data; and
 - Calculated uncertainty around estimates.
- **Nevertheless, our estimates are subject to limitations, uncertainties, and biases.**

Conclusions, Continued

- **These estimates should not be interpreted as suggesting that all foods in a specific food category are equally likely to transmit pathogens.**
- **Caution should also be exercised when comparing estimates across years, as a decrease in a percentage may result, not from a decrease in the number of illnesses attributed to that food, but from an increase in illnesses attributed to another food.**
- **These estimates are for 2013 and do not include recently reported outbreaks from 2014-2017.**

Conclusions, Continued

- **This robust analytic approach facilitates IFSAC's ability to produce regularly updated, harmonized attribution estimates, which provide consistency in the use and interpretation of estimates across agencies.**
- **These estimates can inform food safety decision-making and provide pathogen-specific direction for reducing foodborne illness.**
- **Annual updates to these estimates will enhance IFSAC's efforts to inform and engage stakeholders, and further the ability to assess whether prevention measures are working.**
- **IFSAC continues to enhance attribution efforts by working on projects that address limitations, including further exploration of *Campylobacter* attribution, and inclusion of foods with ingredients assigned to more than one food category.**



Question and Answer Period

Please contact us!

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IFSAC Webpage:

<http://www.cdc.gov/foodsafety/ifsac/index.html>