Surveillance Networks and the detection and Investigation of Foodborne Disease Outbreaks

What You See is What you Get

10th CSL/JIFSAN Symposium
Methods and Systems for Tracking, Tracing and Verifying Foods
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University of Maryland
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Foodborne disease - 2009
a continuing public health concern

- **Common:**
  - 76 million cases of disease each year, and 5,000 deaths
  - ~1,300 outbreaks reported each year
  - Outbreaks a small part of problem; most reported cases are "sporadic"

- **Complex:**
  - At least 250 different diseases
  - Huge variety of foods

- **Continuing:**
  - Some progress in last decade
  - New problems need new strategies for prevention
  - Many partners from farm to table

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Our public health infrastructure

- The county or city health department
  - The front line of public health
- The state health department
  - Epidemiologists
  - Laboratorians
  - Sanitarians
- The federal agencies:
  - Risk identification agency: CDC
  - Risk management/regulatory agencies: FDA, USDA, EPA

- Tiered response to emergencies. CDC provides back-up to State HDs: epidemiologists, laboratory support, coordination, and leads nationwide outbreak investigations

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Centers for Disease Control and Prevention

- Agency of the Department of Health and Human Services
  Many are officers in the U. S. Public Health Service
- Established in Atlanta in WW2 to control malaria
  Result: malaria eradicated
- 1948: *Salmonella* reference laboratory established
- 1951: Emergency response mission; the Epidemic Intelligence Service created, and the "Epi-AID" investigation

- Teams of epidemiologists, microbiologists, statisticians, and other public health professionals

- Largely Non-regulatory – we provide independent scientific assessment to the regulatory agencies and other partners

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CDC roles in surveillance, and outbreak detection and investigation

- **Supports and maintains surveillance systems for nationally notifiable diseases**
- **Develops and supports public health subtyping networks that help detect outbreaks**
- **Leads and coordinates investigations of outbreaks that affect many states at once, or are particularly severe, unusual or large**
- **Provides training in public health methods**
- **Maintains scientific expertise in pathogens and specific problems, advising partners and colleagues globally**

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We investigate outbreaks in order to

- Prevent additional cases in the current outbreak
- Identify a new pathogen or problem
- Determine what went wrong in order to prevent future similar outbreaks
  - Define higher risk foods
  - Define gaps in the system
  - Stimulate further specific research
  - New processes or regulations

- Outbreak investigations are a major driver for enhancing overall food safety

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Some recent large multi-state outbreaks of foodborne infections 2006-2009

2006 - *E. coli* O157 and bagged spinach
2006 - *E. coli* O157 and shredded lettuce (restaurant chain A)
2006 - *E. coli* O157 and shredded lettuce (restaurant chain B)
2006 - Botulism and commercial pasteurized carrot juice
2006 - *Salmonella* and fresh tomatoes
2007 - *E. coli* O157 and frozen pizza
2007 - *Salmonella* and peanut butter
2007 - *Salmonella* and a vegetarian snack food
2007 - *Salmonella* and dry dog food
2007 - *Salmonella* and microwaveable pot pies
2007 - *Salmonella* and dry puffed rice breakfast cereal
2007 - E. coli O157 and ground beef
2007 - Botulism and canned chili sauce
2008 - *Salmonella* and cantaloupe
2008 - E. coli O157 and ground beef
2008 - *Salmonella* and fresh produce items
2009 - *Salmonella* and peanut butter containing foods
2009 - *Salmonella* and imported white and black pepper

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•A new food vehicle in 11/18 outbreaks

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The spectrum of foodborne disease outbreaks

➢Focal scenario

- Large number of cases in one jurisdiction
- Detected by affected group themselves
- Local investigation
- Local food handling error
- Local solution

➢Dispersed scenario

- Small numbers of cases in many jurisdictions
- Detected by lab-based subtype surveillance
- Multistate investigation
- Industrial contamination event
- Broad implications

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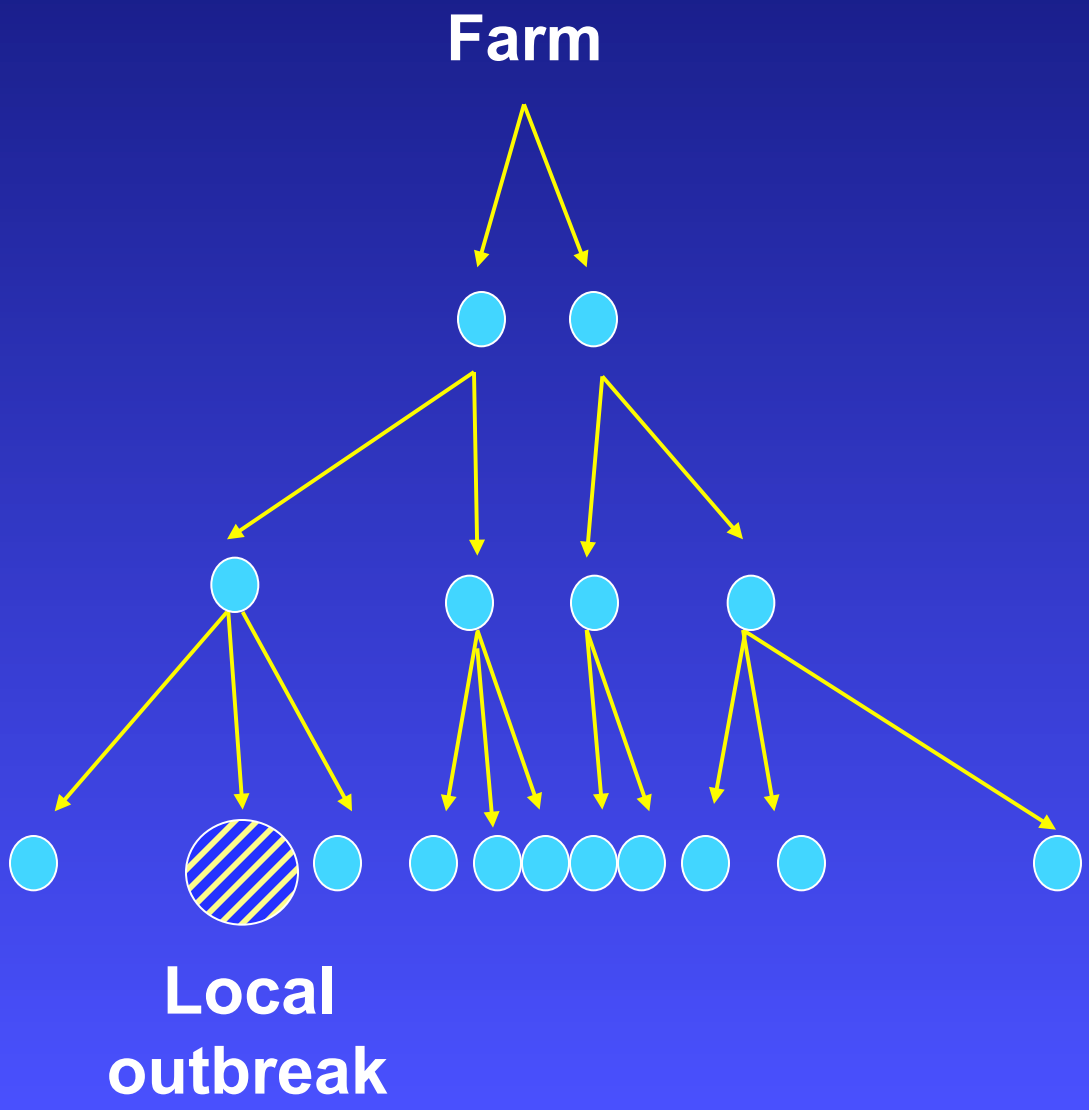
The locus of contamination in the chain of production defines the spread of the outbreak

Production

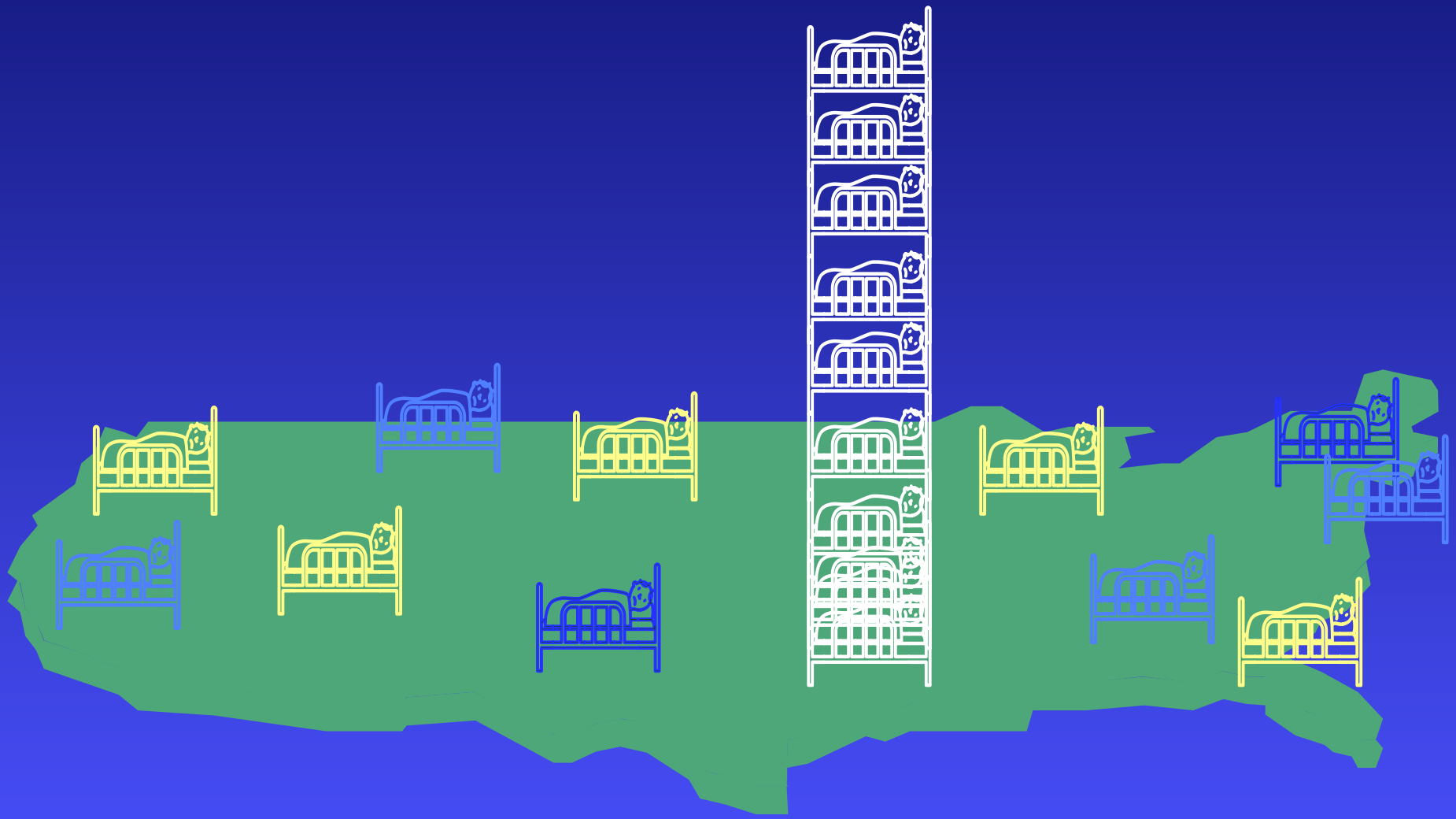
Processing

Distribution

Final kitchens



A large outbreak in one place may be obvious



Almost any surveillance system will detect this event

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The locus of contamination in the chain of production defines the spread of the outbreak

Production

↓

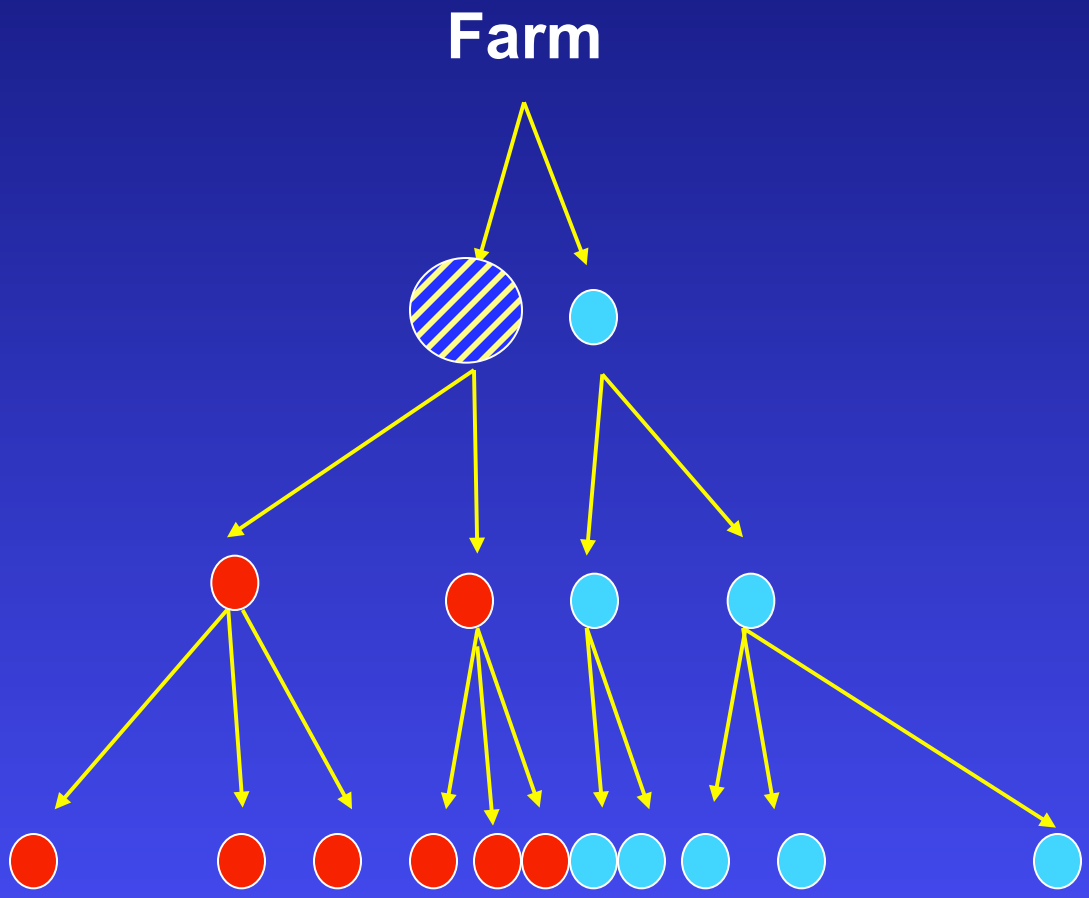
Processing

↓

Distribution

↓

Final kitchens



DIffuse outbreak

The locus of contamination in the chain of production defines the spread of the outbreak

Production

↓

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↓

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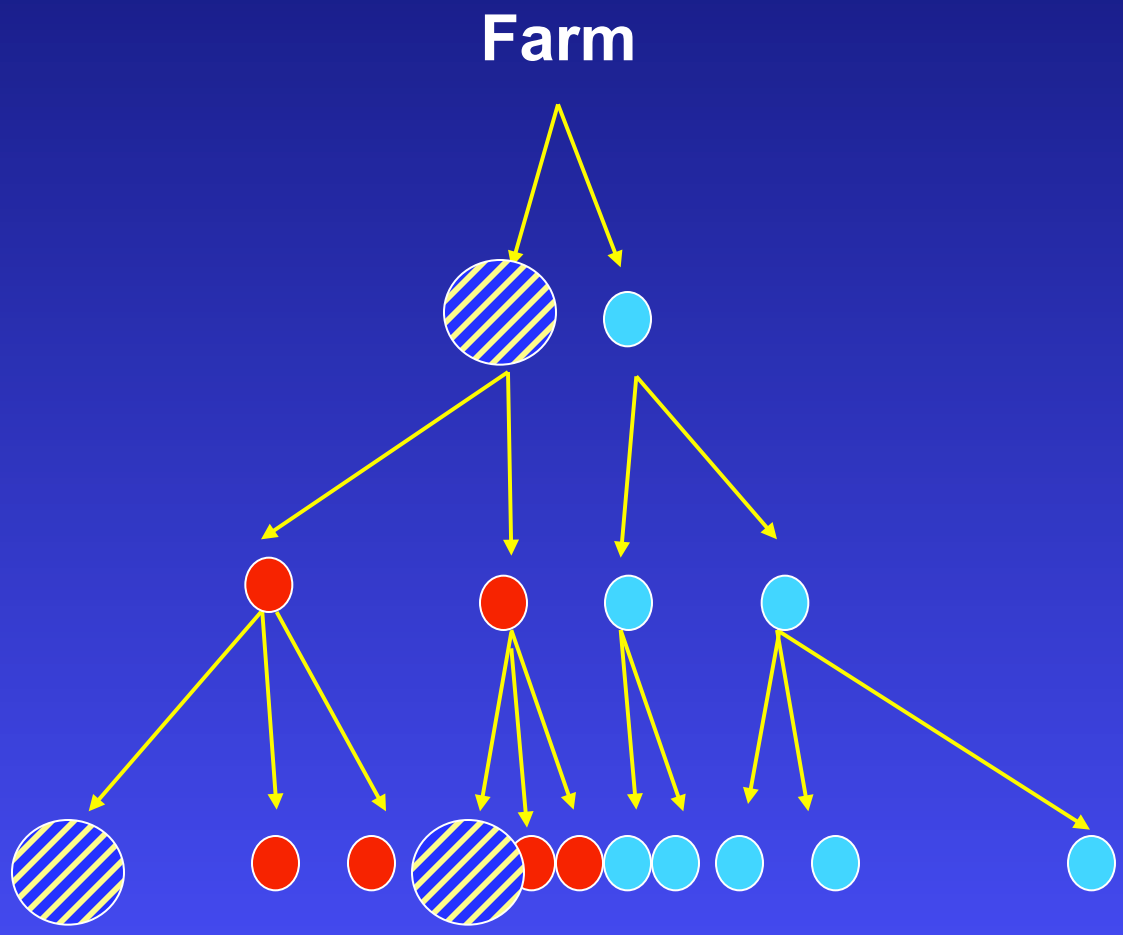
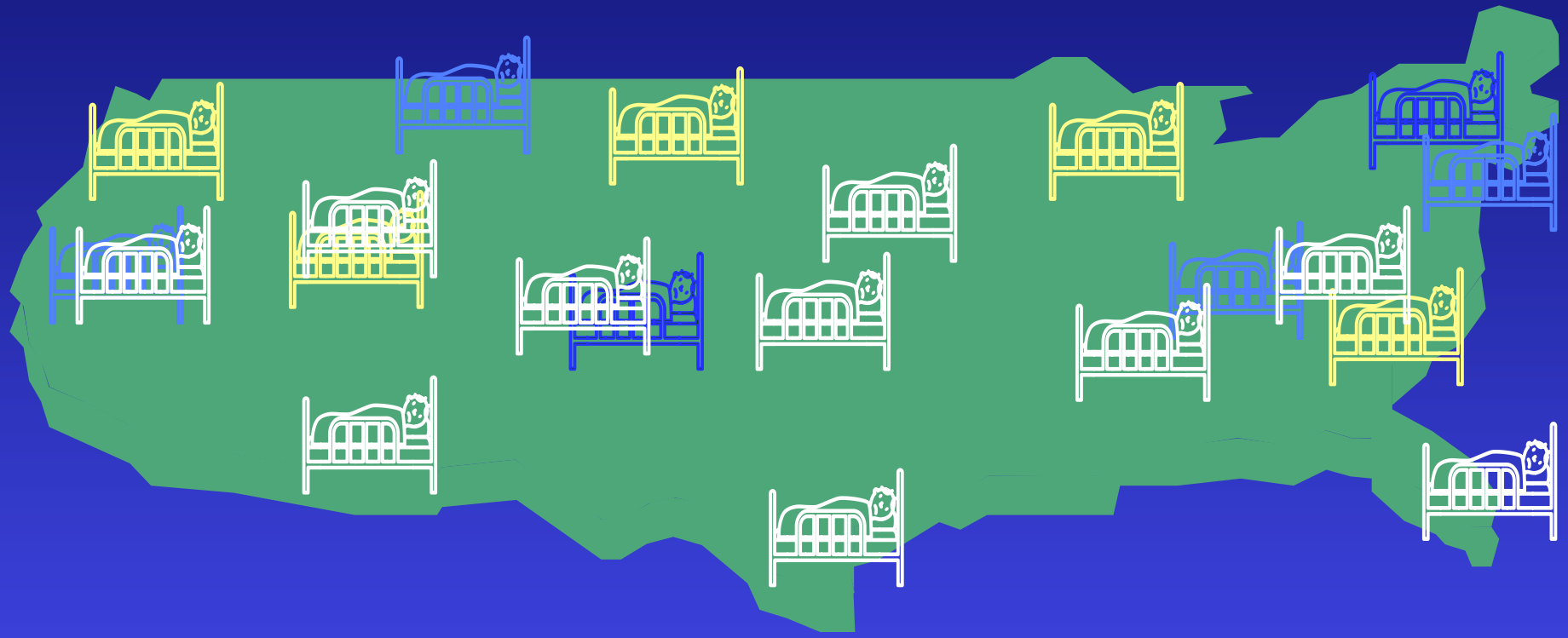
↓

Final kitchens



D I f f u s e o u t b r e a k
with focal events embedded in it

A dispersed outbreak may be difficult to detect, unless



- We test bacteria from all the cases, and
- We find they are infected with the same bacterial strain, and different from other similar illnesses

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Two networks for foodborne disease outbreak investigation

- PulseNet
  - National network of federal (CDC, FDA and USDA), state, and local laboratories that perform standardized molecular subtyping of foodborne bacterial pathogens
  - Electronic sharing of DNA ‘fingerprint’ patterns permits rapid detection of clusters of strains from ill persons that have matching patterns
  - Facilitates detection and investigation of dispersed common-source outbreaks that cause few cases in individual jurisdictions

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Two networks for foodborne disease outbreak investigation

- OutbreakNet Team at CDC
  - Coordinates an informal national network of federal, state and local public health officials who investigate outbreaks of foodborne, waterborne and other enteric illnesses
  - Helps to ensure rapid, coordinated detection and response to dispersed multistate outbreaks of foodborne illness
  - Works in close partnership with PulseNet and with liaisons from FDA and USDA at CDC

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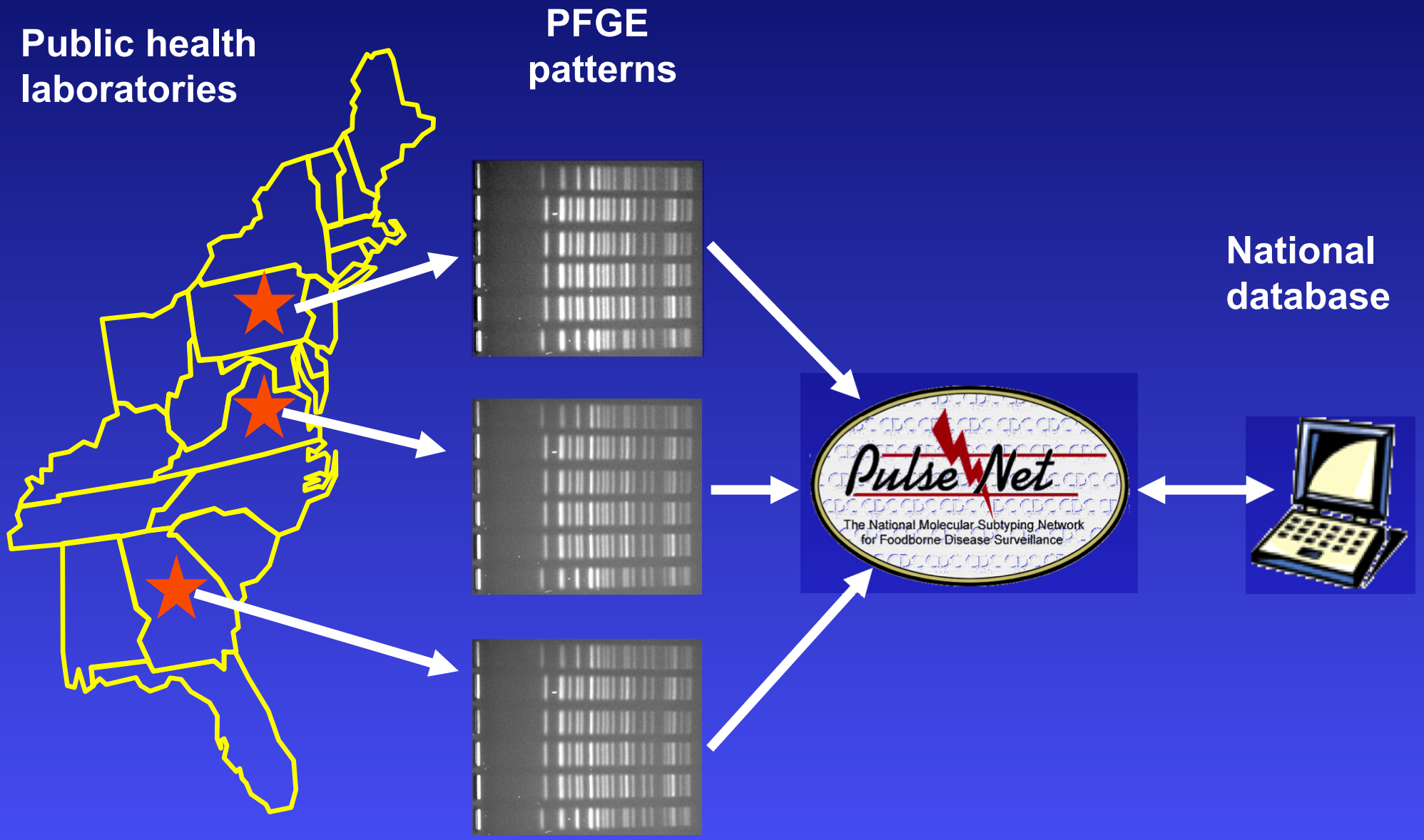
Trends in multistate dispersed foodborne disease outbreaks

- Molecular surveillance of enteric bacterial pathogens has resulted in enhanced detection of outbreaks that could not have been identified through traditional epidemiological methods alone
  - Outbreaks due to pathogens that are so common that clusters are hidden among sporadic cases
  - Dispersed common-source outbreaks that cause few cases in individual jurisdictions

- This in turn is driving change in other parts of the public health and food safety systems

State laboratory coordination in PulseNet



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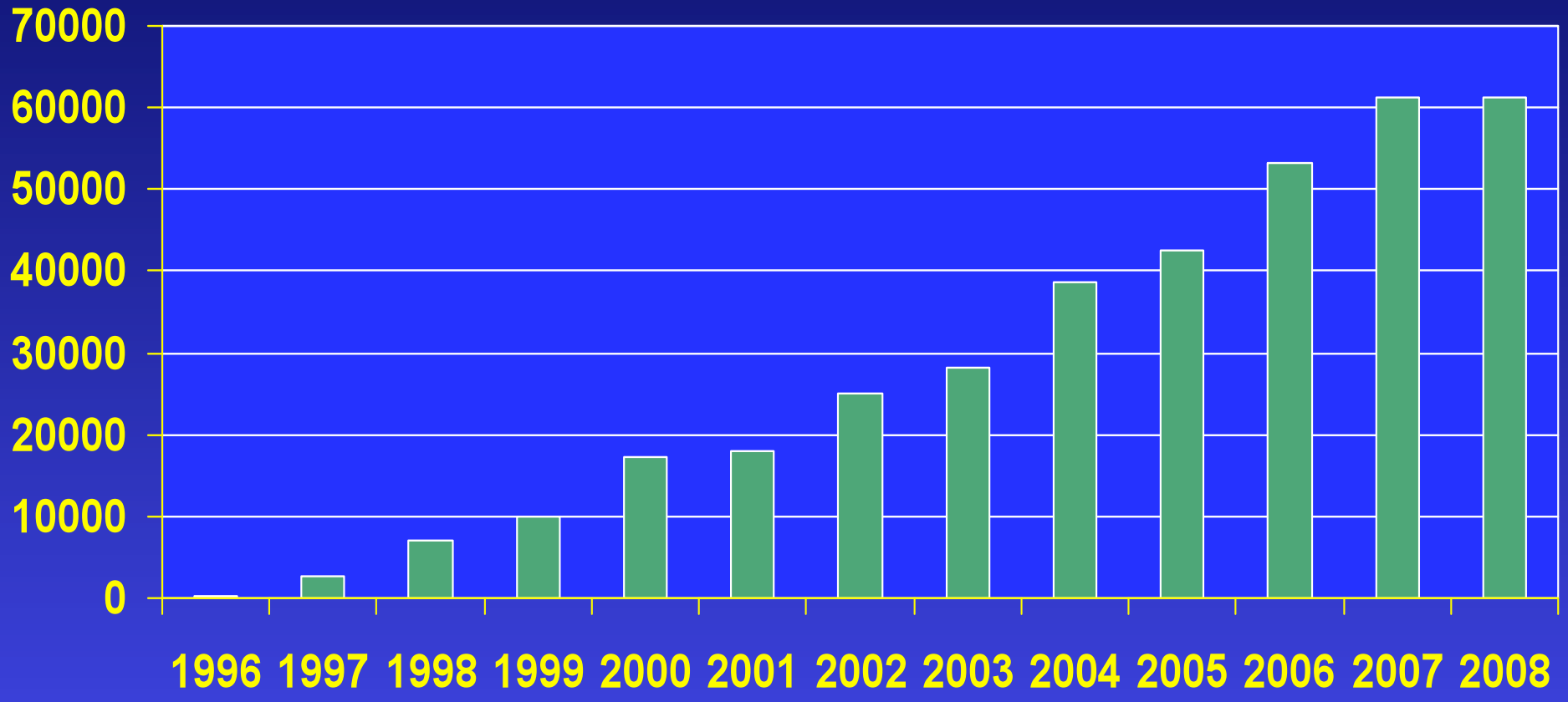
PFGE patterns uploaded to PulseNet databases, by year, 1996-2008



Bacteria: Mainly *E. coli* O157, *Listeria monocytogenes*, *Salmonella*
Coming soon: CaliciNet, CryptoNet, and HAVNet

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Stages in a foodborne outbreak investigation

- Detection: "Is something unusual happening? To whom?"
- Developing hypotheses: "What was likely on the menu?"
- Testing hypotheses: "Which foods were associated with illness?"
- Traceback and environmental assessment: "Where did that food come from, and what happened to it along the way?"
- Control: "Is that contaminated food no longer available?
- Long term prevention: "What needs to change to keep something like this from happening again?"

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How to investigate a multi-state cluster What, if anything, do these people have in common? Hypothesis Generating Interviews

- **Strategies include:**
  - **Interviews with structured questionnaire with many food items on it: "trolling, trawling, or shotgun"**
  - **Intensive open-ended interviews about everything that went into patient's mouth in the last 5 days**
    - **In-depth interview with people in their homes,**
    - **Looking into refrigerator, pantry**
  - **Some combination of the two**
  - **All must be done the same way**

- **Not all outbreaks are from a food product!**

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How to investigate a multi-state cluster
Analytic studies to test hypotheses

- **Short list of likely foods and other exposures**

- **Structured interviews: a case-control study**
  - **Ill persons with the outbreak strain**
  - **Well people of similar age in the same area**

- **Compare the results statistically to see which foods are most strongly associated with illness**

- **Review what we know about that food to makes sure**
  - **It is plausible**
  - **The distribution of the food fits the distribution of cases**
  - **Evidence of dose-response, or explanation of outliers**

- **Seek leftover foods to culture**

Hypothesis-driven source tracing

- "Epidemiological traceback", "rapid look back"
- Can be critical to help to implicate a food item
- Important for foods that are "generic" or co-linear
  - E.g. lettuce vs tomatoes at restaurants
  - E.g. shredded cheese vs shredded lettuce at a taco chain
- Can be done quickly, if not for regulatory purposes
- Potential for confusion – if interpreted by industry as traceback of an implicated product

Close collaboration with regulatory partners FDA and USDA/FSIS

- **Both established in 1906, with different responsibilities and authorities, covering different food types**
- **Both have large inspection and enforcement activities**
- **Both have liaisons at CDC, who know about the cluster investigations as they develop**
- **They are informed as evidence points to one of their foods**
- **They lead the traceback and in-plant investigations**
- **They test foods, and participate in PulseNet**

One challenge: triaging the many clusters that PulseNet detects

- **50,000 strains are reported to PulseNet each year**
- **Thousands of pattern types – many thousands of "matches"**
- **A group of strains with a matching pattern = "cluster"**
- **Local clusters are detected locally, state clusters detected at state level**
- **CDC focuses on multi-state clusters, ~300 each year**
  - **How severe is the illness? *E. coli* O157, *Listeria* at top**
  - **Is the number of cases in the cluster increasing?**
  - **Is the number of affected states increasing?**
- **Ramp up investigation of expanding clusters**

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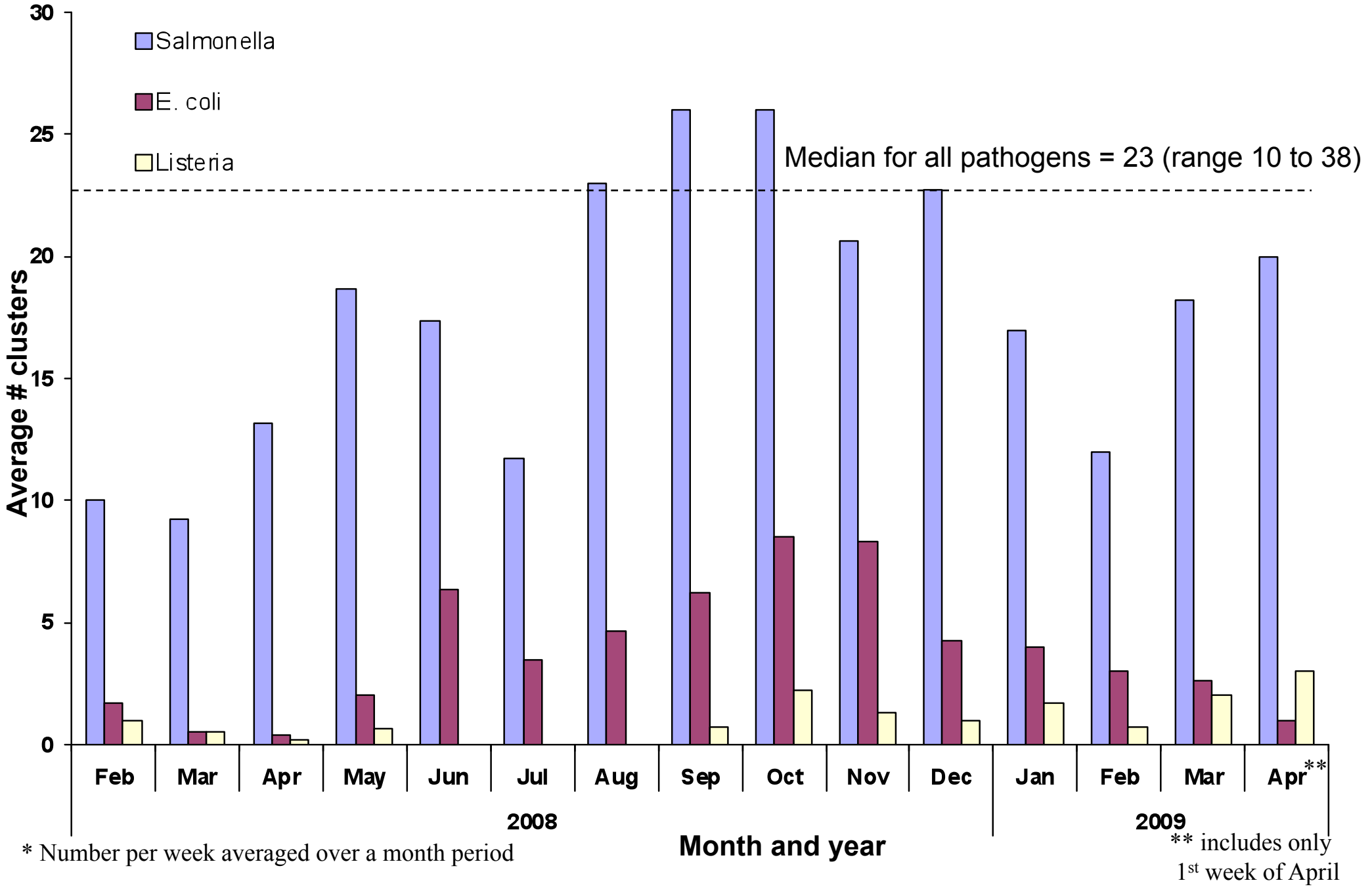
Average Weekly Number* of Clusters CDC OutbreakNet Team Followed by Month and Pathogen, February, 2008 – April, 2009



* Number per week averaged over a month period

** includes only 1st week of April

A second challenge: Making our processes for surveillance and investigation faster

- **What did people eat in the days before they got sick.**
- **We may be interviewing them a month later.**
- **One option: interview everyone with a long questionnaire as soon as their infection is reported (*Salmonella*, or *E. coli*, etc)**
- **Then put the questionnaires together when PulseNet defines the cluster**
- **Requires dedicated resources to conduct the interviews**
- **We do this now for *Listeria monocytogenes***

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Timeline for Reporting of Cases

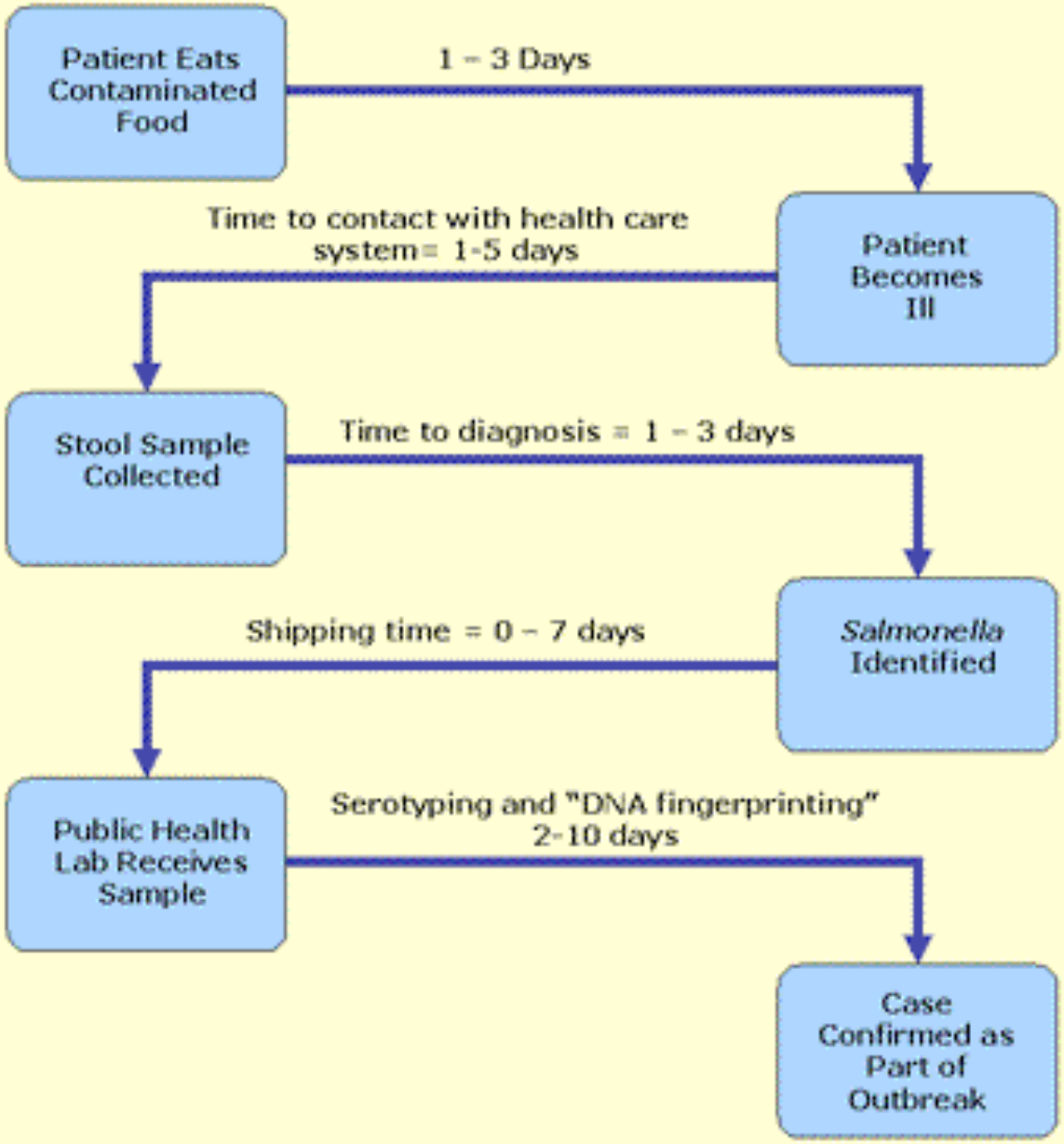
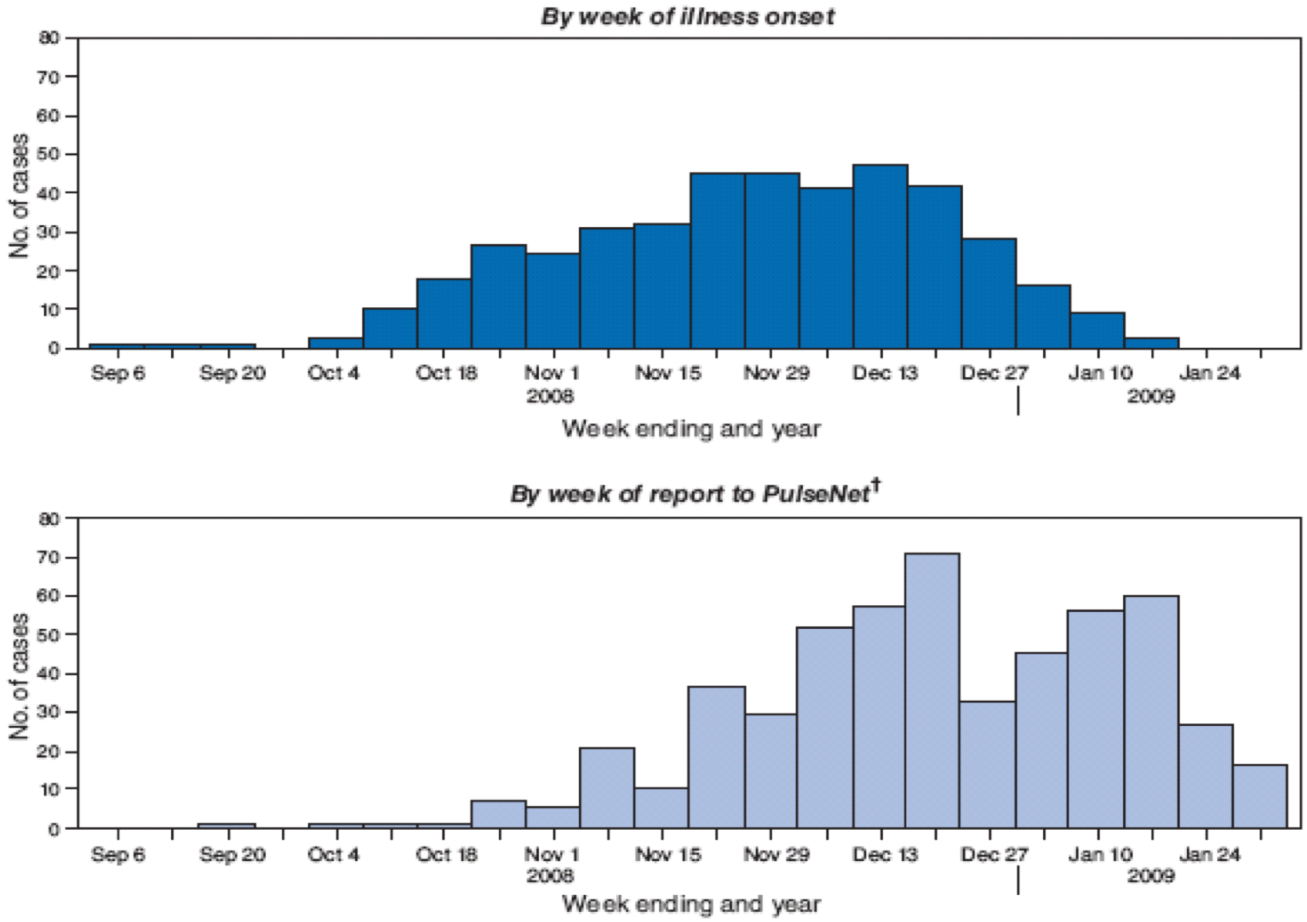


FIGURE 2. Number of laboratory-confirmed cases (N = 529)* of *Salmonella* Typhimurium infection with the outbreak strain associated with peanut butter and peanut butter–containing products — United States, 2008–2009



* Cases reported as of January 28, 2009. Cases beginning in the most recent 3 weeks might not yet be reported.
† The national molecular subtyping network for foodborne disease surveillance.

Median 16 day lag between onset of illness and date pattern uploaded to PulseNet (was 30 days in peanut butter outbreak two years ago)

Morbidity & Mortality Weekly Report 2009: vol 58, p85-90, Feb 5

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A third challenge: Bringing standardization to the epidemiological process

- Each state or county has authority to interview cases
- Resources, training and methods vary widely
- Dispersed outbreaks require consistent approach
- Often encouraging local health authorities to re-interview with a new standard form
- Initial interview with a standard questionnaire would take more time but collecting consistent information would greatly accelerate investigations

A fourth challenge: Building international collaboration

- 15% of our food supply comes from other countries
- The source of seed, feed, food ingredients, as well as final food items is often international
- We export a great deal of food ourselves
- Of 33 international outbreaks (1988-2004), 3 were global, affecting 3 or more continents
- International collaboration in surveillance, investigation and control is critical to long term improvements

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Strengthening public health globally

- Training and support via several collaborative networks
  - **TephiNet**: Training programs in field epidemiology in 55 other countries (like EIS at CDC)
  - **WHO Global SalmSurv**: Training microbiologists and epidemiologists in 80 countries on the basic methods for foodborne pathogens
  - **PulseNet International**: Now have PulseNet Canada, PulseNet Latin America, PulseNet Europe, PulseNet Asia/ Pacific, and PulseNet Middle East (41 countries)
- Better detection of global outbreaks

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Foodborne diseases in the 21st century

- Foodborne diseases will continue to be a major public health problem
- New pathogens, new foods in new combinations
  - Animal reservoirs
  - Fresh produce
  - Processed foods
- Critical attention to ecological settings in which we raise animals and plants
- Robust public health networks for surveillance and investigation of foodborne infections
- Multi-state, multi-national outbreaks require strong collaborations across agencies and countries

"Food safety recalls are always either too early or too late. If you're right, it's always too late. If you're wrong, it's always too early."

Paul Mead

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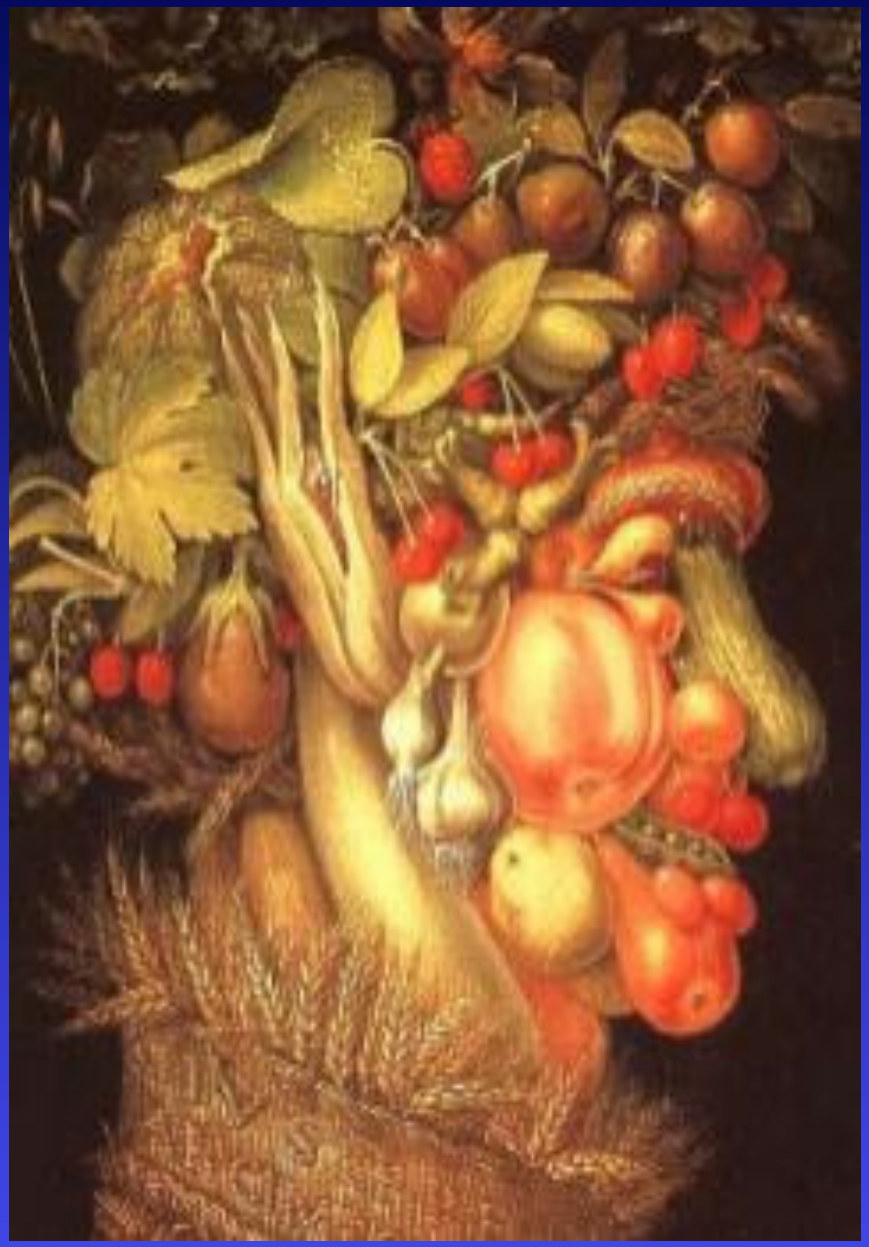

Thank you

The findings and conclusions in this presentation are those of the author and do not necessarily represent the views of the Centers for Disease Control and Prevention

Our websites

Salmonella:
http://www.cdc.gov/salmonella

FoodNet:
http://www.cdc.gov/foodnet

PulseNet:
http://www.cdc.gov/pulsenet

Foodborne outbreak surveillance:
http://www.cdc.gov/foodborneoutbreaks

CDC Safe Water System:
http://www.cdc.gov/safewater

General Information About Diseases:
http://www.cdc.gov/health

Themes in recent multistate outbreaks

- Detected with molecular subtype-based national surveillance
- Investigations can be prolonged, and depend critically on local and state health department capacity to
  - Investigate cases in detail
  - Detect and investigate localized events
  - Collaborate with other jurisdictions
- Epidemiological investigation → traceback, control
  - Before pathogen isolated from product
- Fresh produce
  - Leafy greens, peppers, tomatoes, carrots, cantaloupes
  - Produce easily contaminated in field
  - Complex ecologies link pastures, streams, and produce fields
- Processed foods contaminated in factory
  - Snacks, peanut butter, dog food kibble, pot pies, frozen pizza
  - Major sanitation issues in food factories
  - Better strategies for inspection and prevention

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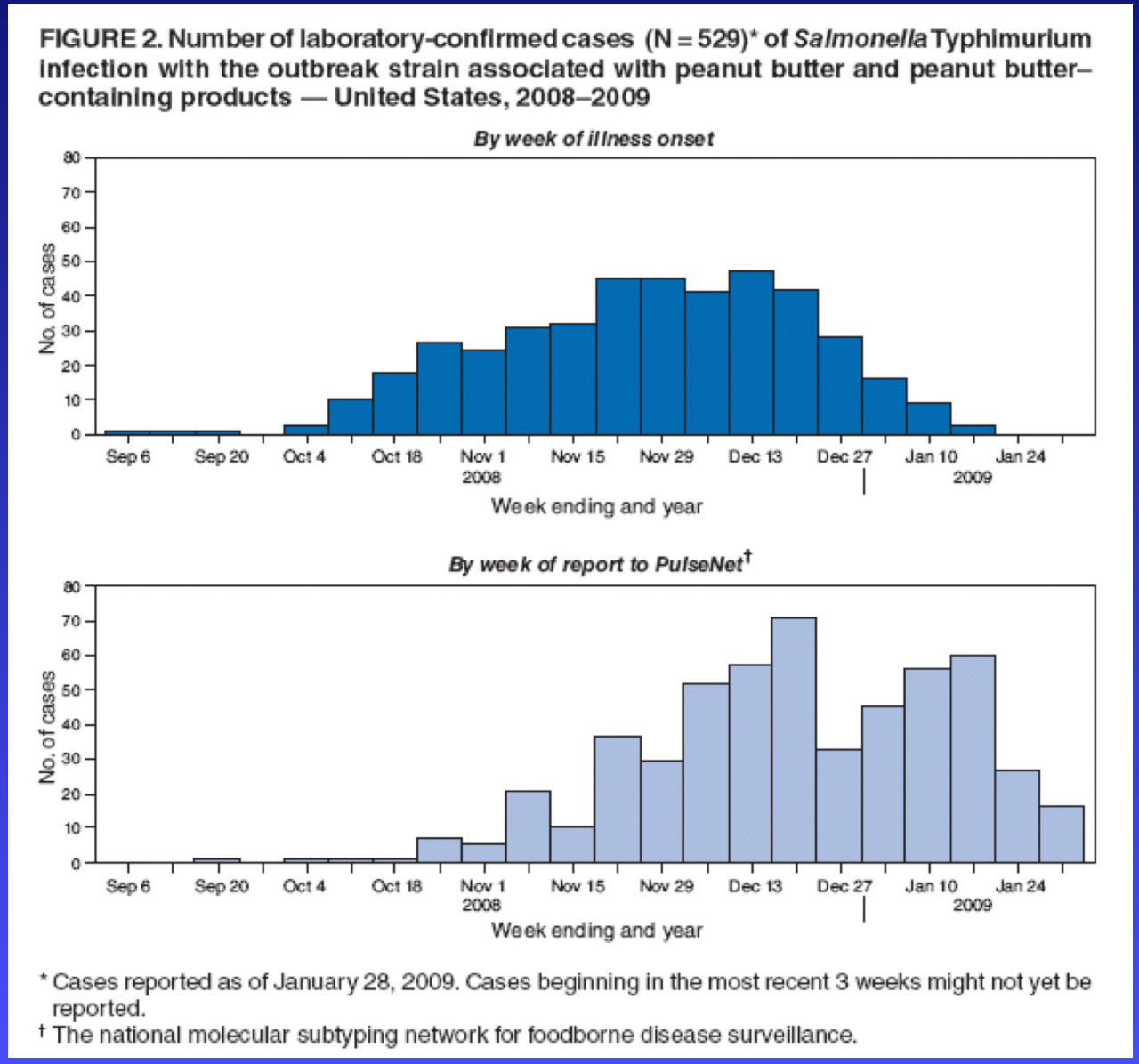
Salmonella Typhimurium infections and peanut butter-containing products – 2008-2009



MMWR 58: p85-90, Feb 5, 2009

Nov 10, cluster of 13 noted,
Nov 25, began HGI Institutional foci, led to Brand X Peanut Butter,
Jan 10, 1st recall

As of March 17,
691 cases
46 states,
23% hospitalized
9 deaths

Median 16 days time lag between onset of illness and upload to PulseNet

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Salmonella Typhimurium infections and peanut butter-containing products – 2008-2009

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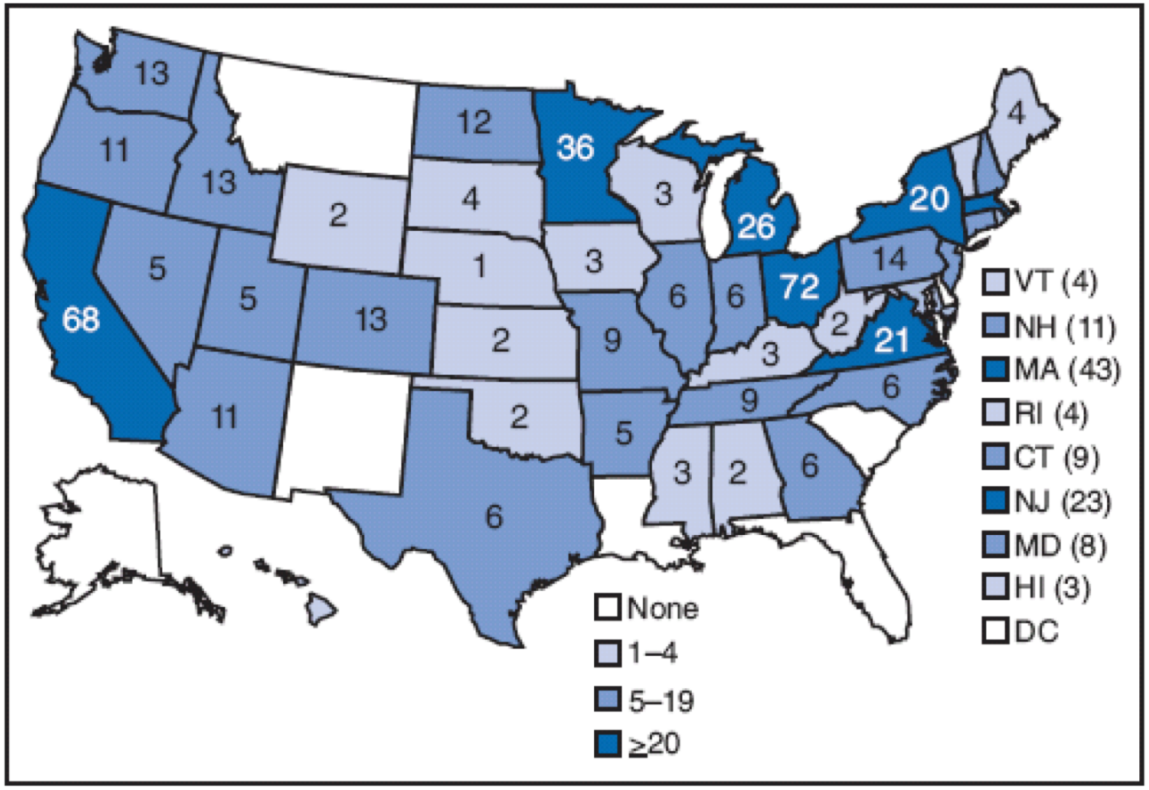

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MMMWR 58: p85-90, Feb 5 2009

Findings preliminary and may change

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Salmonella Typhimurium infections and peanut butter containing products – lessons learned

- Peanut butter one food vehicle of this large outbreak
- Peanut paste used in vast array of other products
- Produced by one company with poor hygiene

- Highly dispersed outbreak depends on local and state capacity
  - Would not have been identified without PulseNet
  - Detailed local investigations of small clusters critical

- Highlights epidemiological challenges
  - Time lags in surveillance and investigation
  - The "stealth" vehicle: King Nut brand peanut butter
  - The "ingredient-driven" outbreak – 3,500 products recalled
  - The "long-tailed" outbreak – products with long shelf lives

- Current inspection practices did not prevent this outbreak

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Since 1996, public health surveillance for foodborne diseases enhanced

- **Standard notifiable disease reporting: All 50 states:**
  - **Added *Listeria*, non-O157 Shiga toxin prod. *E. coli, Vibrio***
  - **Serotyping of *Salmonella*, *Shigella* strengthened**
  - **Added antibiotic resistance monitoring (NARMS)**

- **FoodNet: Active sentinel 10-site surveillance collects data about sporadic cases. Burden and trend monitoring.**

- **PulseNet: The national subtyping network for bacterial foodborne pathogens: All 50 states. Improved outbreak detection and investigation.**

- **Electronic Foodborne Outbreak Reporting (eFORS): Reporting foodborne outbreak investigations to CDC via the web**

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Local Public Health Department
Call from the bride's family about many illnesses following the wedding reception

- **What is the illness? Interview a handful of ill people**
- **What is the microbiological cause? Arrange to get samples from ill people sent to the Public Health Laboratory**

- **What was the food (or other) vehicle?**
  - **Epidemiologist needs two things:**
    - **Guest list**
    - **Menu of items served**
  - **Contact everyone on the guest list**
    - **Review the menu with each, asking what they ate**
    - **Test association between illness and each food item**
    - **Statistics really helps**

- **What happened that led to the outbreak?**
  - **Sanitarian checks out the caterer**
  - **Local corrective measures as needed**

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Testing the hypotheses
General approaches

- Analytical epidemiological study
  - Multistate case-control study
  - Investigation of one or more local events
  - Epidemiological source tracing
- Finding the pathogen in the product, after suspecting it in an outbreak
- Variant: Pathogen detected in the product in absence of known outbreak

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