FOOD ATTRIBUTION
Concepts & Challenges

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UF Emerging Pathogens Institute

Created in 2006, new building in Feb 2010
Goal is to use research, training, and education to protect public health and economy

RESEARCH AREAS:

- Plants
- Animals
- Infectious disease
- Food safety
The Food Safety Research Consortium

Multidisciplinary collaboration between eight research institutions, with a focus on developing decision tools and facilitating dialogue to make food safety more science-based, risk-informed, and data-driven
FSRC and food attribution

- Food Attribution Workshop
  - Atlanta, GA: October 2003

- International Conference on Priority Setting for Foodborne & Zoonotic Pathogens
  - Co-convened w/ MED-VET-NET, Berlin: July 2006
"I can’t win with these salmonella outbreaks. My favorite is peanut butter and raw spinach sandwiches."
Why do we care?

To know how and where to intervene to prevent foodborne illnesses, we need to understand:

- What pathogens are making people ill
- The pathways that lead to exposure – foods, water, pets, travel, etc
- Factors affecting contamination, growth, and exposure along the farm-to-fork continuum
What is making people sick?

Salmonella-related recall grows in products containing seasoning HVP

By Lynne Terry, The Oregonian
March 11, 2010, 3:57PM

The Food and Drug Administration released a flurry of recalls today over salmonella fears associated with a savory seasoning that is added to a slew of food.

Seven companies, including Kroger Co., which owns Fred Meyer, recalled two dozens items, including dips, soup, seasoning and gravy mix. All of them contain hydrolyzed vegetable protein from Basic Food Flavors in Las Vegas.

One lot of the company's HVP tested positive for salmonella sparking an inspection of the company's plant, which turned up more of the bacterium.

Hydrolyzed vegetable protein is used in place of MSG by manufacturers and adds a savory kick to food.

The FDA has set up a database for the HVP-related recall, adding new products every day. About 150 products have been pulled so far.

No illnesses have been reported.
What is “food attribution?”

- Pires et al. (2009)*:
  - “Human illness “source attribution” may be defined as the partitioning of the human disease burden of one or more foodborne infections to specific sources, where the term source includes animal reservoirs and vehicles (e.g., foods).”

- Generally applied in a preventative context
  - Estimating national attribution for a number of pathogens and/or a number of foods

Decision contexts

- **Specific burden**: How effective will an intervention be for a specific product?
  - How many illnesses are caused by food-pathogen pair $F_1P_1$?

- **Relative burden**: Where should we intervene for a specific pathogen?
  - For pathogen $P_1$, how are illnesses distributed foods $F_1$ to $F_n$?

- **Risk ranking**: How should we allocate resources across potential hazards?
  - Which food-pathogen pair has the greatest burden, across all $F_iP_j$?

- **Global burden**: Which are the riskiest foods?
  - How many illnesses are caused by food $F_1$ across all pathogens $P_j$?
Point of attribution

Animal reservoirs

Point of processing

Point of consumption/exposure

Farm → Slaughter → Processing → Retail → Consumption → Illness

Seafood

Egg layers

Cattle, Pigs, Poultry

Wildlife

Household pets

Transmission routes

Environment

Beef, Pork, Poultry meat

Beef, Pork, Poultry meat

Beef, Pork, Poultry meat

Egg products

Table eggs, Seafood

Direct contact

Person-to-person

Illness

Produce

Water

Travel abroad

Food categorization

- Categorization matters if we’re aggregating or comparing
- Tougher than it seems
  - Each study has it’s own set of categories
  - Different points of attribution call for different types of categories
- Start with species, but other issues
  - Complex foods
  - Fuzzy food boundaries: (e.g. sprouts, sliced deli meats)
  - Differentiating by origin (domestic vs imported), processing (raw, canned, frozen), location of preparation (home, restaurant)
- Need a consensus hierarchical categorization scheme that would work across methods
# Example: categorizing outbreaks

<table>
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<tr>
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<tbody>
<tr>
<td>Poultry</td>
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<td>Land animals</td>
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<tr>
<td>Red meat</td>
<td></td>
<td>- Poultry</td>
</tr>
<tr>
<td>- Beef</td>
<td>Beef</td>
<td>- Beef</td>
</tr>
<tr>
<td>- Pork</td>
<td>Pork</td>
<td>- Pork</td>
</tr>
<tr>
<td>- Lamb</td>
<td>Other meats</td>
<td>- Game</td>
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<tr>
<td></td>
<td>Game</td>
<td>- Eggs</td>
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<tr>
<td>Eggs</td>
<td>Eggs</td>
<td>- Dairy</td>
</tr>
<tr>
<td>Milk &amp; Dairy</td>
<td>Dairy</td>
<td>Aquatic animals</td>
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<tr>
<td>Seafood</td>
<td>Seafood</td>
<td>- Fish</td>
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<tr>
<td>- Fish</td>
<td>- Finfish</td>
<td>- Shellfish</td>
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<tr>
<td>- Shellfish</td>
<td>Produce</td>
<td>Plants</td>
</tr>
<tr>
<td>Vegetables &amp; fruit</td>
<td>- Fruits</td>
<td>- Fruits/nuts</td>
</tr>
<tr>
<td></td>
<td>- Vegetables</td>
<td>- Vegetables</td>
</tr>
<tr>
<td>Rice</td>
<td>Breads and Bakery</td>
<td>- Grains/Beans</td>
</tr>
<tr>
<td>Complex foods</td>
<td>Beverages</td>
<td>- Oils/sugars</td>
</tr>
<tr>
<td></td>
<td>Multi-ingredient foods</td>
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</tbody>
</table>

A bevy of methods

1. Microbial subtyping
2. Outbreak analysis
3. Case-control studies
4. Natural experiments
5. Comparative exposure assessments
6. Elicitation of expert judgment
1. Microbial subtyping

- Link isolates from human cases to those from animals or foods using one of many “microbial fingerprinting” methods
  - Serotyping, phage-typing, PFGE, MLST, MLVA, etc.

- Key idea: different animals are reservoirs for distinct species of zoonotic pathogens

- Example:
  - Danish Salmonella Accounts (Tine Hald)
Microbial subtyping (cont’d)

- **Pros:**
  - Directly links human and animal data
  - Can be highly accurate under right conditions

- **Cons:**
  - Animal focused – environmental/water/produce pathways get attributed to reservoir animal
  - Requires a lot of data – both human and animal/food

- **Useful for:** targeting on-farm controls and evaluating them over time
2. Analyzing outbreak data

- Extrapolate patterns from data aggregated geographically and temporally (e.g. at the national level, based on 10 years of data)

- Many examples:
  - CSPI (Caroline Smith DeWaal)
  - CDC (John Painter et al)
  - USDA (Erin Dreyling/Curtis Travis),
  - UK (Bob Adak et al)
  - FSRC (me!)
  - Canada (Grieg and Ravel)
Outbreaks (cont’d)

- **Pros:**
  - Large nationwide dataset, many pathogens
  - Straightforward; uses common data

- **Cons:**
  - Misrepresents sporadic cases, geographic inconsistencies
  - Biases towards large events, certain foods
  - Overestimates role of produce
    - Many outbreaks caused by mistakes in preparation
    - Cross-contamination is unidirectional – from animal products

- **Useful for:** understanding broad system-wide patterns of risk
3. Case-control studies

- Case-patients are matched to set of uninfected controls (by age, gender, etc);
  - cases & controls are interviewed about behavior and food consumption
  - statistical analysis show deviations b/w cases & controls, associations made w/ significant risk factors

- Examples:
  - FoodNet case-control studies
Case-control (cont’d)

Pros:
- Population-based (capture sporadic cases)
- Less selection bias
- Identify new or additional risk factors

Cons:
- Long exposure windows; multiple sources of exposure
- Common exposures less likely to be identified
- Recall bias - reliant on interviews
- No laboratory confirmation of source of illness

Useful for: Understanding interplay between foods and behavior
- E.g. Salmonella case-control study showed protective effect of breast feeding
4. Natural experiments

- Can be due to unintentional changes (e.g. food shortage, mass recalls, outbreak) or intentional changes (e.g. regulatory action) that can be quantifiably associated with changes in illness.

- **Pros:**
  - Specific association is made for a particular food or set of foods.

- **Cons:**
  - Rare “silver lining” snapshots in time.
  - Unavailable for most food items.

- **Useful for:** Understanding role of single item.
5. Comparative exposure assessments

- Predictive microbiology models estimates illnesses for number of significant exposure pathways, based on contamination rates at point of attribution
- Example: Dutch Campylobacter studies (Eric Evers)
Exposure assessment (cont’d)

□ Pros:
  ■ Estimates illnesses often not captured by epi data
  ■ Furthers understanding of risk transmission
  ■ Can test hypotheses through modeling

□ Cons:
  ■ Resource intensive
  ■ Major data gaps

□ Useful for: Identifying interventions across spectrum of pathways for a single pathogen of concern
6. Expert elicitation

- Experts are elicited using one of several established, structured protocols
- Results can be qualitative, semi-quantitative, or quantitative
- Examples:
  - FSRC elicitation (Sandy Hoffmann)
  - USDA elicitations (for RBI)
Experts (cont’d)

- **Pros:**
  - Can reconcile disagreeing data, fill gaps
  - Increasingly recognized and accepted

- **Cons:**
  - Not “data driven” in traditional sense
  - Biases and circularity

- **Useful for:** Integrating results – experts could be provided with outbreak analysis, case-control studies, exposure assessments, and asked to weigh them
A bevy of methods (revisited)

1. Microbial subtyping
2. Analysis of aggregated outbreaks
3. Studies of sporadic disease
4. Intervention studies
5. Comparative exposure assessments
6. Elicitation of expert judgment
Challenges

- Time marches on (out of date analysis)
- Changes in population immunities and in pathogen antimicrobial resistance
- Interpreting/comparing studies
- Uncertainties

Future needs

- Common terminology / consensus on hierarchical food categories
- Contamination data on broad range of products
- Better link human and animal/food data
- Methods for combining or integrating results
Any questions?

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