Source Attribution Models for *Salmonella* serotype Enteritidis Infections

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Why Is “Attribution” So Difficult?
Because the food that caused a person’s illness is usually not known

- Ill people rarely know what food made them ill
  - may not realize it was food
  - often wrong when guess a food

- Food source can often be determined in outbreaks
  - but <5% of even lab-confirmed illnesses occur in outbreaks

- Case-control studies of sporadic (non-outbreak) cases can estimate likely sources for a population
  - by comparing exposures of sporadic cases with those of well people
  - but cannot identify with certainty the source of anyone’s illness
Background

- *Salmonella* serotype Enteritidis (SE) is now most commonly isolated serotype from humans, accounting for ~20% isolates.


- FDA estimated Egg Rule would prevent many SE infections.

- Method needed to estimate % of illnesses due to shell eggs:
  - % before the Egg Rule
  - % after the Egg Rule

www.fda.gov/food/guidanceregulation/guidancedocumentsregulatoryinformation/eggs/ucm170615.htm
Interagency Food Safety Analytics Consortium (IFSAC)

- Formed in 2011 as a collaboration among
  - Centers for Disease Control (CDC)
  - Food and Drug Administration (FDA), and
  - U.S. Department of Agriculture (USDA)
    Food Safety and Inspection Service (FSIS)

- To improve coordination of federal food safety analytic efforts
  - Current focus is estimating sources of specific foodborne illnesses

- For the SE attribution project, an IFSAC project team provided input on data, methods, and time period of analysis
Major Data Sources for Attribution Analyses

- Outbreak data
- Studies of sources of sporadic cases
- Surveys of contamination of foods
- Food consumption data
  - FoodNet Population Survey
  - NHANES
  - other
Project Team Evaluated Two Models

- Food contamination model
- Exposure model
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Food Contamination Model  
(Hald Model)

- Developed by Tine Hald of Denmark and used in several countries

- Uses Bayesian approach to
  - estimate sources of *Salmonella* infections, and
  - detect changes in sources over time

- Types of data needed
  - food contamination data (or surrogate)
  - data on SE subtypes in people and food
  - food consumption data

- Model includes variables to account for
  - Food source factors: food processing and preparation practices
  - Pathogen factors: severity of illness
Food Contamination Model 
(Hald Model)

- Had only some of the data needed
  - food contamination data (or surrogate)
    - Data on meat products ✓
    - Data on shell eggs ✗
  - data on SE subtypes in people and food ✗
  - food consumption data ✓

- Could not create the model
Project Team Evaluated Two Models

- Food contamination model
- Exposure model
Major Data Sources for Attribution Analyses

- Outbreak data
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- Surveys of contamination of foods
- Food consumption data
  - FoodNet Population Survey
  - NHANES
  - other
Exposure Model: Types of Data Available

- Foodborne outbreak data from entire country
- Case-control study of sporadic SE infections in FoodNet sites in 2002

*FoodNet covers 15% of US population in 10 sites*
Foodborne Outbreak Data, 2002-2009

- 76 SE outbreaks reported with ingredients in a single food category, 2002-2009

- Estimated % illnesses* due to each food category (95% confidence interval)
  - Shell eggs 57% (45-68%)
  - Chicken 22% (13-32%)
  - Beef 7% (1-12%)
  - Produce 5% (0-10%)

*more accurately, the population attributable fraction (PAF)
FoodNet Case-Control Study Conducted in 2002

- Re-analyzed data using a new statistical approach
  - Grouped exposures into food categories
  - Determined reductions in infections following complete removal of each exposure

- Estimated % of illnesses due to each food category (95% confidence intervals)
  - Shell eggs 22% (9-32%)
  - Chicken 11% (2-25%)
  - Beef 9% (2-18%)
  - Produce 9% (3-15%)

Gu. Epidemiol Infect 2015
Created an Exposure Model by Blending the Two Types of Data

- Gave each data type equal weight

- Able to estimate sources for 72% of SE domestically-acquired foodborne illnesses
  - Shell eggs 40% (30-51%)
  - Chicken 16% (8-31%)
  - Beef 8% (3-15%)
  - Produce 8% (4-13%)

- The other 28% of illnesses could be due to these or other food categories
Some Assumptions, Decisions, and Limitations

- **Outbreak data**
  - Used number of outbreaks rather than number of outbreak illnesses
  - Used 8 years of data (2002-2009) to estimate sources in 2007-2009
  - Do not know how well these illnesses represent sporadic illnesses

- **Sporadic case-control data**
  - Used data from 2002 to estimate sources in 2007-2009
  - Do not know how well these illnesses represent illnesses in entire country, including illnesses not lab-confirmed

- **Blending method empiric: used 50/50**

- **Estimated only foodborne illnesses**
  - Created another model to incorporate data associated with foreign travel and animal exposure
Plans for Using the Model to Generate Estimates for a Period After the Egg Rule

Incidence (FoodNet)

- International travel
- Domestic infections
- Foodborne
  - Animal contact
    - Chicken
    - Shell eggs
  - Blending model

Exposures among outbreak illnesses
Exposures among sporadic illnesses