Attributing Illness to Disaggregated Food Categories Using Expert Opinion and Consumption Data


October 3-4, 2013
Motivation

- Regulators make decisions about how to target scarce inspection resources
- Need to understand prior to consumer or food service handling the likelihood that a food
  - Is contaminated and
  - Will cause illness
- Available data is very limited
  - Most data are from outbreak investigations
    - Non-representative
    - Biased toward large outbreaks, short incubation periods, and more serious illnesses
Task Objectives

- Utilize expert elicitation to:
  - Develop disaggregated food categories into smaller homogeneous groups with respect to microbiological contamination likelihood
  - Generate estimates of % of FBI attributable to contamination that occurs before the product reaches the store shelf (excluding contamination resulting from inappropriate handling at retail and/or the home)

- Calculate attribution rates for each disaggregated food category and pathogen pair using
  - Expert opinion data collected, AND
  - Consumption data
Why Expert Elicitation?

- Lack of studies with directly relevant data
- Other methods of research synthesis not feasible
- Considerable amount of related data and knowledge
  - Overall prevalence of foodborne illness in the United States
  - Understanding of microbial growth under different conditions and in different food types
  - Effectiveness of “kill steps” between manufacturer and the consumer
- Synthesis of inputs from multiple types of experts
Methods

- Modified Delphi technique
  - Panel of 16 experts
  - Experts interact through a moderator
  - Iterative approach to eliciting opinion
  - Mathematical aggregation of opinions
  - Accounts for uncertainty through self-assessed confidence ratings

- Combine expert elicitation data with consumption data
- Avoids “anchoring” on outbreak-based studies
More on Attribution Method

- Even very high-risk foods may account for very few FBI if rarely eaten
- Percentage of FBI attributable to a specific food-pathogen pair is a function of relative likelihood of contamination AND share of consumption
Questionnaire Design

- Supermarket concept
  - Offers natural groupings of products
  - Reduce cognitive burden on experts
- MS Excel-based self-administered questionnaire
Round 1

- **Objective:** Identify food-pathogen combinations of *most concern* for further evaluation in the next round

- **Questions:**
  - Pathogens that are of most concern for a given food product category
  - Product subcategories for which the likelihood of contamination is higher than average
## Relevant Food Categories by Pathogen from Round 1

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Number of Relevant Food Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astrovirus</td>
<td>14</td>
</tr>
<tr>
<td>Bacillus cereus</td>
<td>121</td>
</tr>
<tr>
<td>Brucella</td>
<td>3</td>
</tr>
<tr>
<td>C. botulinum</td>
<td>110</td>
</tr>
<tr>
<td>Campylobacter</td>
<td>45</td>
</tr>
<tr>
<td>Clostridium perfringens</td>
<td>67</td>
</tr>
<tr>
<td>Cryptosporidium parvum</td>
<td>102</td>
</tr>
<tr>
<td>Cyclospora cayetanensis</td>
<td>71</td>
</tr>
<tr>
<td>Escherichia coli spp.</td>
<td>231</td>
</tr>
<tr>
<td>Giardia lamblia</td>
<td>31</td>
</tr>
<tr>
<td>Hepatitis A</td>
<td>138</td>
</tr>
<tr>
<td>Listeria monocytogenes</td>
<td>172</td>
</tr>
<tr>
<td>Norwalk-like viruses</td>
<td>135</td>
</tr>
<tr>
<td>Rotavirus</td>
<td>26</td>
</tr>
<tr>
<td>Salmonella spp.</td>
<td>353</td>
</tr>
<tr>
<td>Shigella</td>
<td>116</td>
</tr>
<tr>
<td>Staphylococcus</td>
<td>96</td>
</tr>
<tr>
<td>Streptococcus</td>
<td>14</td>
</tr>
<tr>
<td>Toxoplasma gondii</td>
<td>14</td>
</tr>
<tr>
<td>Trichinella spiralis</td>
<td>4</td>
</tr>
<tr>
<td>Vibrio spp.</td>
<td>35</td>
</tr>
<tr>
<td>Yersinia enterocolitica</td>
<td>32</td>
</tr>
</tbody>
</table>

### Brucella
- **Round 1 Start**: 96 Food Categories
- **Round 1 End**: 3 Food Categories

### Salmonella spp.
- **Round 1 Start**: 96 Food Categories
- **Round 1 End**: 353 Food Categories
Round 2

• **Objective:** Compare the relative likelihood of contamination for all food categories associated with each pathogen

• **Question:**
  • Group food categories provided according to relative likelihood of contamination into following bins
    • Negligible
    • Low
    • Medium:Low
    • Medium:Medium
    • Medium:High
    • High:Low
    • High:Medium
    • High:High
Round 3

- **Objective:** Estimate FBI due to contamination that happens during harvest, processing, and/or distribution stages of the farm-to-fork continuum, i.e., relevant at time of importation

- **Question:**
  - Estimate % of FBI that might occur due to events after the product is sold, e.g., due to improper handling at retail and/or home

\[
\% \text{ FBI due to Contamination that Occurs Before the Product Reaches the Store Shelf} = 1 - \% \text{ FBI due to Contamination that Occurs After the Product Leaves the Store Shelf}
\]
Attribution Rate Methodology

- **Step 1:** Map expert defined food categories to Nielsen scanner food categories
- **Step 2:** Normalize weighted mean contamination likelihood scores such that the sum of the scores across food categories for a food pathogen equals 100%
- **Step 3:** Use Nielsen sales equivalent units as proxy for consumption volume
- **Step 4:** Calculate raw attribution rate as:
  
  \[
  \text{Weighted Normalized Mean Relative Contamination Likelihood Score} \times \text{Consumption Share in } \%
  \]

- **Step 5:** Normalize raw attribution rate such that the sum of the attribution rates for each food for a given pathogen equals 100%
Considerations

- Other research methods are not feasible due to lack of studies
- Government analysts are time and budget constrained
- Expert elicitation is challenging and requires innovative approaches
- Integration of expert elicitation with other data sources
- Continued development of better methods to meet these challenges is needed