Understanding the human health burden of *Salmonella* from the meat supply

Reciprocal Meat Conference 2006

Fredrick Angulo, DVM PhD
Chief, FoodNet/NARMS

Enteric Diseases Epidemiology Branch (proposed name)
Centers for Disease Control and Prevention
CDC’s Role

**Mission**: reduce the human health burden of foodborne diseases

- Independent risk assessment
  - Non-regulatory
- Close collaboration with state health depts
  - National surveillance programs
    - FoodNet, NARMS, PulseNet, OutbreakNet
  - Field investigations
    - At invitation of states
What is FoodNet?

- Foodborne Diseases Active Surveillance Network
  - Established in 1996
- Principal foodborne disease component of Emerging Infections Program
- CDC, USDA-FSIS, FDA, and participating state health departments
FoodNet Surveillance

- Active surveillance for laboratory-confirmed infections
  - *Salmonella*, *Shigella*, *Campylobacter*, Shiga-toxin producing *E. coli* (including *E. coli* O157), *Listeria monocytogenes*, *Yersinia enterocolitica*, *Vibrio*, *Cryptosporidium* and *Cyclospora*

- FoodNet personnel ascertain cases from >600 clinical laboratories serving the FoodNet catchment area
FoodNet Sites 2005

44 million (15% of U.S. population)
FoodNet Objectives

1. **Determine the burden** of foodborne illness in the United States

2. **Monitor trends in the burden** of specific foodborne illness over time

3. **Attribute the burden** of foodborne illness to specific foods and settings

4. **Develop and assess interventions** to reduce the burden of foodborne illness
FoodNet provides

- Stable, comprehensive, consistent surveillance
  - Overall burden of illness estimates
  - Annual trend estimate
    “National Report Card” on the food safety system
    - Monitor progress towards National Health Objectives
  - Source estimate and evaluation of interventions
- Critical data for national food safety policy
Determine burden

- Surveillance: “tip of the iceberg”
- Depends on several factors
  - Medical care seeking behavior
  - Diagnosis, Reporting
- *Salmonella* causes, each year
  - >1 million infections
  - >100,000 doctor visits
  - >30,000 laboratory-confirmed cases
  - >10,000 hospitalizations
  - 500 deaths
Monitor trend

- Published each year in mid-April in CDC’s MMWR publication
- Measuring change in incidence compared to 1996-1998 baseline
- Use negative binomial regression model to account for:
  - Increase in number of participating sites
  - Site-to-site variation in incidence
Trend in *E. coli* O157

- Continued decline in *E. coli* O157 infections not sustained in 2005
  - Compare to 1996-1998 baseline, *E. coli* O157 decreased 29% in 2005

- Consistent with FSIS data on *E. coli* O157 contamination of ground beef
## Healthy People 2010 Objectives

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>2004</th>
<th>2005</th>
<th>2010 Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEC O157</td>
<td>0.9</td>
<td>1.06</td>
<td>1.0</td>
</tr>
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</table>
E. coli O157 Success Story

- Coordinated efforts by regulators and industry effective in reducing contamination and illness related to ground beef
- Survey with America Meat Institute to document changes in industry practices
  - What factors contributed to the decline of STEC O157 contamination on ground beef?
## Healthy People 2010 Objectives

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Cases per 100,000</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>2004</td>
</tr>
<tr>
<td>Salmonella</td>
<td>14.7</td>
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</table>
FIGURE 2. Relative rates compared with 1996–1998 baseline period of laboratory-diagnosed cases of infection with the five most commonly isolated *Salmonella* serotypes, by year.
Trends in *Salmonella*

- Little change
  - Compared to 1996-1998 baseline, *Salmonella* decreased 9% (CI = 2%–15%) in 2005

- Of the five most common *Salmonella* serotypes, only the incidence of S. Typhimurium decreased
  - Most change occurred prior to 2000
Steps to reducing *Salmonella*?

- USDA initiative to reduce the presence of *Salmonella* in raw meat and poultry products
  
  - Need to know source of human infections
    - Animal reservoir species and transmission routes
  
  - Good attribution for *E. coli* O157
  
  - Attribution for *Salmonella* more complex
    - Wide variety of food-animal products
    - Information on attribution differs by serotype
CDC attribution efforts

- Start with human illness data
  - Attribute to different sources
  - “Top down” qualitative risk assessment approach (“Fork-to-farm” approach)

- Can partition illness at various steps throughout the food supply
  - Point of consumption
  - Point of processing
  - Reservoir
‘Point of consumption’ attribution

• Foodborne Disease Outbreaks
  – Major enhancements provided by PulseNet and OutbreakNet
  – Summarize data from all reported outbreaks
  – Complex problem due to food categorization

• FoodNet sporadic case-control studies
  – 18 FoodNet case-control studies completed
Sporadic case-control studies

• FoodNet case-control studies on different Salmonella serotypes

• Recently completed study on infant cases of *Salmonella* infections
  – New risk factor: Being in shopping cart with raw meat or poultry

• In 2006, FoodNet will launch a 12-month study of *S. Javiana*, *S. Infantis* and *S. I4,[5],12:i:-*
Blending Project

- **e.g. E. coli O157:H7**
  - Summary of outbreaks*
    - 20% due to eating hamburgers
    - 4% due to animal contact
  - FoodNet sporadic case-control study
    - 15% due to eating pink hamburgers
    - 8% due to visiting a farm

*Rangel et al.  EID 11:603-9, 2005
'Point of Processing' Attribution

- Quantify the contribution of meat and poultry as a source of human Salmonellosis

- Data sources
  - Public Health Laboratory Information System
  - USDA, FSIS Hazard Analysis and Critical Control Points (HACCP)
Salmonella Attribution Project

- *Salmonella* attribution project, with USDA-FSIS and University of Minnesota
  - Comparing subtypes from humans and animal-food groups
Trends in sources for human salmonellosis

Source: Danish Zoonosis Centre
FoodNet Priorities

1. Attribution
2. Attribution
3. Attribution
4. Multidrug-resistant *Salmonella*
National Antimicrobial Resistance Monitoring System (NARMS)

- In 1996, FDA Joint Advisory Committee recommended the creation of surveillance system to monitor development of antimicrobial resistance among foodborne bacteria
  - Financially supported by FDA-Center for Veterinary Medicine

- Integrated surveillance (*Salmonella, Campylobacter*)
  - CDC: Human surveillance
    - Nationwide
  - FDA-CVM: Retail meat surveillance
    - FoodNet sites
  - USDA: Animal surveillance (On Farm & Slaughter)
Human Health Consequences

- Accumulating evidence of human health consequence of resistant *Salmonella*
  - Increased severity of illness
  - Increased death
- *Salmonella* treatment failures due to resistance to clinically important antimicrobial agents
  - Third generation cephalosporin
    - Ceftriaxone (humans), ceftiofur (animals)
Proportion of S. Newport multidrug-resistant and resistant to ceftiofur

% Resistant

Multidrug-resistant

+ Ceftiofur

NARMS

Surveys

Year

0 5 10 15 20 25 30

80 85 90 95 96 97 98 99 00 01 02 03

CDC
Percent of *Salmonella* Typhimurium isolates with multidrug ACSSuT resistance pattern (1980 – 2004)

NARMS launched

Surveys

ACSSuT
Ampicillin (A)
Chloramphenicol (C)
Streptomycin (S)
Sulfonamide (Su)
Tetracycline (T)
Percentage of S. Typhimurium resistant to at least ACSSuT, by year, 1996-2004*

34% in 1996 to 23% in 2004

OR=0.6 [95% CI 0.4, 0.8]

* 2004 preliminary data
Multistate Outbreak of MDR *Salmonella* Typhimurium DT104 in the Northeast, 2003-2004

- Multistate outbreak from contaminated ground beef purchased in grocery stores
  - First documented outbreak of MDR *S.* Typhimurium DT104 from widely distributed food item in the U.S.
- Ground beef originated from one cattle slaughterhouse, suspected source culled dairy cows
- New cases after investigation suggesting continued exposure to contaminated ground beef
Culled Dairy Cows: An Invitation for Resistance and Spread?

- Regular antimicrobial use during life of cow
  - Calves fed medicated milk replacer
  - Waste milk (milk from cows on antimicrobials) given to calves
  - Adult cows given antimicrobials to prevent disease

- Time of slaughter
  - Reason for culling?
  - Asymptomatic carriage of pathogenic bacteria
  - Increased excretion at time of slaughter

- Large production facilities
  - 6000-8000 pounds of beef ground at once
  - Contamination of large lots possible with one infected animal
Collaboration to Address the Problem

• “Salmonella DT104 and Ground Beef - Update and Policy Forum” March 2005

• Objectives
  – Address and discuss the human health, veterinary health, regulatory, industry and consumer concerns associated with the contamination of ground beef by multidrug-resistant *Salmonella* including *Salmonella Typhimurium* DT104
  – Address potential solutions to this emerging concern
    • *Clinical Infectious Diseases* 2006
Resistance predictors for ACSSuT
NARMS, 1999-2003*

<table>
<thead>
<tr>
<th>Resistance</th>
<th>PPV</th>
<th>NPV</th>
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<tbody>
<tr>
<td></td>
<td>(95% CI)</td>
<td>(95% CI)</td>
</tr>
<tr>
<td>Chloramphenicol</td>
<td>89.9%</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>(87.6, 91.9)</td>
<td>(100.0, 100.0)</td>
</tr>
<tr>
<td>Chloramphenicol + ampicillin</td>
<td>94.1%</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>(92.2, 95.7)</td>
<td>(100.0, 100.0)</td>
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</tbody>
</table>

Total 8,164 non-Typhi *Salmonella* isolates tested, of which 719 (8.8%) were ACSSuT

Positive predictive value (PPV) = \([\text{test result}(+) \text{ and ACSSuT}(+) / \text{all test result}(+)\] X 100

Negative predictive value (NPV) = \([\text{test result}(-) \text{ and ACSSuT}(-) / \text{all test result}(-)\] X 100
Reduce the Spread of Antimicrobial Resistance

GET SMART, DFBMD

12 Step Program, DHQP
Get Smart on the Farm
Educational Activities to Promote Appropriate Use of Antimicrobial Agents in Animal Health

- Veterinary Curriculum
- State-based Interventions
Animal Health Practices on Washington Dairy Farms

A Tacoma-Pierce County Health Department
Antibiotic Resistance Task Force Project

Primary Investigator: Monica Raymond, MPH, MS, RN
Project Coordinator: Ron Wohrle, DVM
Advisory Board Chairman: Robert Whitney, DVM
FoodNet Conclusions

• Decline in *E. coli* O157
  – Working with AMI to document changes in industry practices

• Little change in *Salmonella*
  – Need to work on attribution for Salmonella to identify sources of human infections
NARMS Conclusions

• MDR infections cause more severe illness
• Trends in resistance high but stable
• Need to identify ways to reduce prevalence of MDR organisms in beef

• Issues:
  – Culled Dairy Cows
  – Predictors for MDR
Acknowledgements

- Industry partners
  - America Meat Institute
  - National Cattlemen’s Beef Association
  - Alliance for Bovine Health
  - Tacoma Pierce County Health Department
  - Washington Dairy Federation
  - American Association of Extension Veterinarians
  - National Pork Board
  - American Association of Bovine Practitioners

- Regulatory partners
  - Food and Drug Administration
  - U.S. Department of Agriculture
http://www.cdc.gov/foodnet
http://www.cdc.gov/narms