E. coli O157:H7 --
Recent data from surveillance and from outbreak investigations, United States

American Meat Institute Foundation Meeting
Arlington, Virginia
January 23, 2008

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Division of Foodborne, Bacterial, and Mycotic Diseases
Center for Zoonotic, Vectorborne, and Enteric Diseases
The fall and rise of reported *Salmonella* infections in the United States, 1920-2006

- Human sewage in human food and water
- Animal manure in human food and water

Data from CDC’s National Notifiable Diseases Surveillance
An outbreak of the deadly bacteria E. coli, traced to fresh spinach, sickens dozens and kills one—and maybe more

Most kids would rather eat marbles than spinach, and 2-year-old Kyle Allgood was no exception. So on Sept. 12 his mother, Robyn, mixed some baby spinach with juice and berries and handed him a smoothie, which he happily guzzled. Three days later Kyle—normally so active his folks called him “the little stuntman”—started having cramps at his home in Chubbuck, Idaho. Five days after that he grew so weak he had to be helicoptered to the Primary Children’s Medical Center in Salt Lake City. “His father told him, ‘Be strong,’ and Kyle said, ‘Okay, Dad,’” recalls his uncle Cliff Oram. “Almost immediately he got calm and his system started to shut down. Then he just slipped away.”

Young Kyle’s death, apparently the result of eating spinach tainted with E. coli, may be linked to a national outbreak of the killer bacteria. As of Sept. 26, 183 people in 26 states from Maine to California have been infected; dozens were hospitalized with cramping, diarrhea and in some cases kidney failure. So far, only one death has been officially tied to the outbreak, but two others—including Kyle’s—are under review. Investigators from the Food and Drug Administration traced the E. coli to bags of fresh spinach grown in three California counties, and the

A FATAL DRINK
Just days after having a spinach smoothie, Kyle Allgood, 2, started cramping and had bloody diarrhea; he died shortly after being airlifted to a hospital. “He was such a happy-go-lucky kid,” says his uncle. “Always in constant motion.”
Topics

- Estimates and clinical illness
- Surveillance data from FoodNet sites
- National surveillance data
- PulseNet
- Modes of transmission and outbreaks
- Impact of surveillance and outbreak investigations
Estimates of annual number of *E. coli* O157 infections, United States

- 73,000 infections
- 2,000 hospitalized
- 60 deaths

*Mead et al. EID 1999*
Sequence of events in *E. coli* O157:H7 infection

- **E. coli** O157 ingested
- 3-4 days: non-bloody diarrhea, abdominal cramps
- 1-2 days: bloody diarrhea
  - 92% resolution in 6 days
  - 8% HUS

*HUS*: Hemolytic Uremic Syndrome
Hemolytic uremic syndrome (HUS)

- Kidney failure, anemia, blood clotting problems
- *E. coli* O157 causes vast majority of cases
- Can affect person of any age
  - Most common in children <5 years old and elderly
- ~5% die

*About half the elderly who die from *E. coli* O157 do not have HUS*
Topics

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- National surveillance data
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- Modes of transmission and outbreaks
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FoodNet catchment, 2006
44 million persons
15% of U.S. population
Determining burden of disease

- Reported to CDC
- Reported to health department
- Clinical lab isolates *E. coli* O157
- Lab tests for organism
- Person submits specimen to lab
- Person seeks care
- Person becomes ill
- Person is exposed
Determining burden of disease

Reported to CDC
Reported to health department
Clinical lab isolates *E. coli* O157
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--- Active surveillance
--- Lab surveys
Population surveys
Determining burden of disease

Reported to CDC
Reported to health department
Clinical lab isolates *E. coli* O157

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Person is exposed

--- Active surveillance

-- Lab surveys

Population surveys
Percent of clinical labs screening all stools for *E. coli* O157

<table>
<thead>
<tr>
<th>Year</th>
<th>National sample</th>
<th>FoodNet sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>'85</td>
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<tr>
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<td>2003</td>
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<tr>
<td>2005</td>
<td></td>
<td>66%</td>
</tr>
<tr>
<td>2007</td>
<td></td>
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</tbody>
</table>

Boyce, *J Clin Micro* 1995; Voetsch *CID* 2004; and unpublished preliminary data
Determining burden of disease

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--- Active surveillance
-- Lab surveys

{ Population surveys
Surveillance for *E. coli* O157 in FoodNet

- **Count**
  - every *E. coli* O157 isolated by clinical labs in the catchment area
- **Calculate incidence (illnesses per 100,000 persons per year)**
  - determine trends over many years
- **Calculate the relative rate compared with baseline years**
Incidence of *E. coli* O157 infections, FoodNet

- Incidence = # illnesses per 100,000 persons per year
- Baseline 1996-98: 2.4
- Healthy People 2010 objective: 1.0
- Recent years
  - 2003: 1.06
  - 2004: 0.90
  - 2005: 1.05
  - 2006: 1.31
We also calculate the relative rate of _E. coli_ O157 infections.

- **Method:** set baseline (years 1996-1998) to arbitrary rate of 1
  - Measure rate each year _relative_ to the baseline rate
- **This method accounts for changes in the FoodNet population over time**
  - Added new sites between 1996 and 2006
  - New sites may have different incidence than old sites
- **Best way to measure trend**
Relative rate
(compared with 1996–1998 baseline period)
of *E. coli* O157 infections, by year, FoodNet

<table>
<thead>
<tr>
<th>Year</th>
<th>Relative rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996-1998</td>
<td>1.0</td>
</tr>
<tr>
<td>1999</td>
<td>0.9</td>
</tr>
<tr>
<td>2000</td>
<td>0.8</td>
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<tr>
<td>2001</td>
<td>0.7</td>
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<tr>
<td>2002</td>
<td>0.6</td>
</tr>
<tr>
<td>2003</td>
<td>0.5</td>
</tr>
<tr>
<td>2004</td>
<td>0.6</td>
</tr>
<tr>
<td>2005</td>
<td>0.7</td>
</tr>
<tr>
<td>2006</td>
<td>0.8</td>
</tr>
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Relative rate (compared with 1996–1998 baseline period) of *E. coli* O157 infections, by year, FoodNet

14% decline from baseline, not a statistically significant difference.
Percent of USDA ground beef samples that yielded *E. coli* O157:H7, 2000-2007

Outbreak with recall of 18 million # ground beef

Source: www.fsis.usda.gov
Percent of people reporting consumption of ground beef in the 7 days before interview, FoodNet Population Survey, 1996-2007

Based on weighted estimates
Percent of ground beef consumers reporting consumption of undercooked (pink) ground beef, in the 7 days before interview, FoodNet Population Survey, 1996-2007

* Based on weighted estimates
Topics

- Estimates and clinical illness
- Surveillance data from FoodNet sites
- National surveillance data
- PulseNet
- Modes of transmission and outbreaks
- Impact of surveillance and outbreak investigations
Incidence of *E. coli* O157 infections, by state, 1999-2002

<table>
<thead>
<tr>
<th>Isolates / 100,000 pop/year</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0 – 6.2</td>
<td>Black</td>
</tr>
<tr>
<td>1.7 – 2.9</td>
<td>Yellow</td>
</tr>
<tr>
<td>0.9 – 1.6</td>
<td>Blue</td>
</tr>
<tr>
<td>0.2 – 0.8</td>
<td>Orange</td>
</tr>
</tbody>
</table>
Incidence of *E. coli* O157 infections, by setting, United States, 1993-1996

Cases/100,000 persons/year

CDC, National Surveillance Data, unpublished
Topics

- Estimates and clinical illness
- Surveillance data from FoodNet sites
- National surveillance data
- PulseNet
- Modes of transmission and outbreaks
- Impact of surveillance and outbreak investigations
What is PulseNet USA?

- National network of >75 public health and regulatory laboratories
- Perform molecular typing of foodborne disease-causing bacteria
  - current method is pulsed-field gel electrophoresis (PFGE)
  - create DNA “fingerprints”
- Share DNA “fingerprints” electronically
- DNA “fingerprints” are kept in dynamic database at CDC
  - available on-demand to participants
The three basic elements of PulseNet

1. Data acquisition
2. Data analysis
3. Data exchange
PulseNet data analysis: searching for clusters

- State health depts submit patterns electronically
- CDC searches for similar patterns in past 2-4 months
- CDC compares patterns visually
- When cluster identified, PulseNet contacts epidemiologists

Cluster of indistinguishable patterns
Using the database, we can answer the question: is this pattern unusual?
Example of outbreak using PulseNet: ground beef outbreak, 2002

- First cases found in Colorado
- PulseNet
  - posted outbreak strain pattern
  - identified 45 persons with outbreak strain in 11 states
- Beef identified as cause
  - Outbreak strain isolated from ground beef
    - beef came from one meat processing plant
- Outbreak stopped after recall of 18.6 million pounds of ground beef
1993: western States *E. coli* O157 outbreak (before PulseNet)

Outbreak detected 1993, 732 ill, 4 deaths. 39 days.

2002: Colorado *E. coli* O157 outbreak (with PulseNet)

Outbreak detected 2002, 45 ill, no deaths. 18 days.
Detections clusters of illness by finding matching DNA “fingerprints”
- facilitates early identification of outbreaks

Assists epidemiologists in investigating outbreaks
- persons with the outbreak “fingerprint” are likely to be part of the outbreak
Submissions to PulseNet of all pathogens continue to rise

PFGE patterns submitted to PulseNet Databases 1996-2007

Submissions to PulseNet of all pathogens continue to rise.
PulseNet *E. coli* database

- ~30,000 fingerprint patterns
- In an outbreak, all people typically have the same pattern
  - isolates from many people with the same pattern count as 1 pattern
Topics

- Estimates and clinical illness
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Animals are the reservoirs for *E. coli* O157

- Cattle: the major reservoir
- Other ruminants: minor reservoirs
- Other animals: minor reservoirs
  - especially those who have contact with cattle or the bovine environment
Major modes of transmission of *E. coli* O157 to humans – how the fecal matter gets to the mouth

- **Food**
  - cattle products, e.g., beef, raw milk
  - food contaminated with cattle or human feces, e.g., lettuce
- **Water contaminated with feces**
  - Drinking water
  - Recreational water
- **Animal contact**
  - contact with farm animals, e.g. petting zoos
  - contact with farm animals’ environment
- **Person contact**
  - With the feces of infected persons
**E. coli O157 outbreaks, U.S., by year, 1982 - 2006**
(N = 525 outbreaks)

- E. coli O157 became nationally notifiable
- PulseNet created
- Large western states outbreak
- Stimulated reporting from States

*Source: Rangel, Emerg Infect Dis, 2005 and unpublished CDC data*
Outbreaks of *E. coli* O157 infections, by State, 1998-2006
Median number of ill persons per E. coli O157 outbreak, U.S., 1982-2006

Median # ill per outbreak

Year

'82 '84 '86 '88 '90 '92 '94 '96 '98 00 '02 '04 '06

Rangel, Emerg Infect Dis, 2005 and CDC unpublished data

5 ill persons/outbreak
Proportion of illnesses due to each mode of transmission in 350 *E. coli* O157 outbreaks, U.S., 1982-2002

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<tr>
<th>Mode</th>
<th>Illnesses in outbreaks (N=8,598 illnesses) %</th>
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<tr>
<td>Foodborne</td>
<td>61</td>
</tr>
<tr>
<td>Drinking water</td>
<td>15</td>
</tr>
<tr>
<td>Unknown</td>
<td>9</td>
</tr>
<tr>
<td>Person-to-person</td>
<td>8</td>
</tr>
<tr>
<td>Animal contact</td>
<td>4</td>
</tr>
<tr>
<td>Recreational water</td>
<td>3</td>
</tr>
<tr>
<td>Lab acquired</td>
<td>&lt;1</td>
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*Rangel, EID, 2005*
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<td>Person-to-person</td>
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<tr>
<td>Animal contact</td>
<td>4%</td>
</tr>
<tr>
<td>Recreational water</td>
<td>3%</td>
</tr>
<tr>
<td>Lab acquired</td>
<td>&lt;1%</td>
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*Rangel, EID 2005*
Proportion of illnesses in *foodborne* *E. coli* O157 outbreaks due to various foods, 1982-2002

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</tr>
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<td>Other beef</td>
<td>11</td>
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<td>6</td>
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(N=5,269 illnesses)

Rangel, EID 2005
Proportion of illnesses in *foodborne* *E. coli* O157 outbreaks due to various foods, 1982-2002

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<td>12%</td>
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*Rangel, EID 2005*
Leafy green vegetables implicated in *E. coli* O157 outbreaks, U.S., 1982 – 2005

- Before 1995: none implicated
- 1995 and 2005: 26 outbreaks
  - Lettuce and lettuce salads: 21 outbreaks
  - Cabbage: 3 outbreaks
  - Parsley: 2 outbreaks
  - Spinach: 1 outbreak

*Cattle are part of this picture*
### Proportion of illnesses in foodborne E. coli O157 outbreaks due to various foods, 1982-2002

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<tr>
<td>Ground beef</td>
<td>33</td>
<td>70% between May and August</td>
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<tr>
<td>Other beef</td>
<td>11</td>
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<tr>
<td>Produce</td>
<td>34</td>
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Beef, 44%

*Rangel, EID 2005*
Percent of foodborne *E. coli O157* outbreaks due to beef, 1982 - 2006

% of outbreaks

Year

*Rangel EID 2005, and CDC unpublished data*
Number of *E. coli* O157 outbreaks with single commodity implicated, by food commodity, 1998-2006

Preliminary data. Excludes outbreaks in which the implicated vehicle contained >1 commodity, e.g., pot roast.
Number of *E. coli* O157 outbreaks with single commodity implicated, by food commodity and year, 1998-2006

Preliminary data. Excludes outbreaks in which the implicated vehicle contained >1 commodity, e.g., pot roast.
Number of *E. coli* O157 outbreaks associated with beef recalls, 2005-2008

*as of January 16, 2008*
E. coli O157 outbreaks associated with beef recalls, 2007

(N = 9 outbreaks)

- 5 multi-state, 4 single state (PA, CA, MN, IL)
- Location of exposure
  - home (7 outbreaks)
  - restaurant (1)
  - concession stand (1)
- Average # persons ill: 10 (range, 2-45)
- Age of ill persons: <1 to 85 years

2 more recalls were related to 1 ill person
E. coli O157 outbreaks associated with beef recalls, by month of first illness onset, 2007
Topics

- Estimates and clinical illness
- Surveillance data from FoodNet sites
- National surveillance data
- PulseNet
- Modes of transmission and outbreaks
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Some impacts of *E. coli* O157 surveillance and outbreak investigations on beef safety

- 1993: Model Food Code for restaurants incorporated temperature guidelines for cooking ground beef
- 1994: *E. coli* O157 made an adulterant in ground beef
  - mandatory recalls
Some impacts of *E. coli* O157 surveillance and outbreak investigations on beef safety (cont.)


- 1996: FoodNet created to track incidence of *E. coli* O157 infections
  - issues annual “report card”
Some impacts of *E. coli* O157 surveillance and outbreak investigations on beef safety (cont.)

- 1996 study: eating from a fast-food restaurant was no longer a risk factor for infection
  - had been risky in a 1990 study

- 2001: beef industry decided to collaborate, not compete, on food safety
Some impacts of *E. coli* O157 surveillance and outbreak investigations on beef safety (cont.)

- 2002: industry began testing all lots of beef trim for *E. coli* O157
  - positive lots not distributed
- 2007: FSIS announced plans to augment inspections
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**E. coli O157**

**Summary of major messages**

- **Clinical illness**
  - Estimate 73,000 ill, 2000 hospitalized, 60 die each year
  - typical illness: diarrhea (often bloody)
  - complications: kidney failure (HUS), death

- **FoodNet surveillance**
  - incidence declined markedly in 2003, met Healthy People objective in 2004
  - incidence increased in 2005 and 2006
    - incidence in 2006 similar to baseline (1996-98)
E. coli O157
Summary of major messages (cont.)

- National surveillance
  - illnesses more common
    - in north than south
    - in rural than urban areas
- PulseNet
  - helps detect and investigate outbreaks
  - increases speed of investigation
Transmission and outbreaks

- cattle are major reservoir
- More *E. coli* O157 outbreaks are due to beef than to any other food commodity
  - In 2006, 25% of foodborne *E. coli* O157 outbreaks were due to beef
  - In 2007, 9 *E. coli* O157 outbreaks led to beef recalls
E. coli O157
Summary of major messages (cont.)

- Surveillance and outbreak investigations stimulate improvements in food safety and provide data to evaluate prevention efforts
This talk was made possible by the efforts of people in many groups, including:

- FoodNet
- PulseNet
- OutbreakNet
- Enteric Diseases Epidemiology and Laboratory Branches, CDC
- State Public Health Departments
Thank you for your attention

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.
MIKE PETERS / Dayton (Ohio) Daily News

ONE TACO....
HOLD THE
LETTUCE, CHICKEN,
SPINACH, BEEF,
CHEESE AND
GREEN ONIONS.

TACO