Escherichia coli O157:H7 and related agents in cattle and other food animals: Biology meets Policy

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Topics

- Animal reservoirs of *E. coli* O157:H7
- Seasonal variation
- Genotypes
- Pre-harvest controls
- Post-harvest controls
- Adulterant status / recalls
- Testing
- Prioritization among food safety pathogens
Animal reservoirs: cattle

- Cattle reservoir
  - Summertime seasonal peak
  - Asymptomatic
  - Transient
  - $<10^2 - 10^5$ cfu/g feces
  - ID$_{50}$ for cattle: $10^2$-$10^3$
  - Immature animals (<2 yrs) more likely infected
Contaminated soil, water, meat, milk, produce, etc.

Infected cattle and other food animals

Infected humans

Other infected animals (e.g., deer, rabbits, rodents, birds, insects, swine, etc.)

Contaminated soil, water, meat, milk, produce, etc.

Human infection
Data from CDC and Stanford et al 2005
Reported E. coli O157:H7 cases, USA: 1994-96

Goal: Eliminate the warm season peaks
**E. coli** O157:H7 is highly clonal

- >90% of isolates share one MLST type
- The first two sequenced strains (EDL933 and Sakai) differ by <100 SNPs
  (Leopold et al., 2009, PNAS)
- EDL933, Sakai, and the ‘Spinach’ outbreak strain share >96% ORFs, >>99% sequence identity among shared ORFs
  (Manning, PNAS 2008)
- Nevertheless, genetic strain differences within **E. coli** O157:H7 have been valuable for both outbreak investigation and for identifying ecological differences within the species
**E. coli** O157:H7 genotypes vary widely in their association with human disease

**E. coli** O157:H7 isolated from human patients fall into two main groups

**E. coli** O157:H7 isolated from cattle are more diverse, and about half of cattle strains are strongly under-represented among clinical isolate
Differential virulence of *E. coli* O157:H7 SBI genotypes in a piglet model
**E. coli** O157:H7 genetic clades

- SNP (and SBI) genotypes:
  - Identify EHEC O157 lineages
  - Are differentially represented in human disease
  - Differ in piglet model virulence
  - Not currently considered, but relevant to both diagnostic and regulatory efforts

- **E. coli** O157:H7 genotypes in the bovine reservoir
  - Are much more diverse than clinical isolates
  - Must be taken into account to understand the full diversity of the species
  - Are hugely under-studied vs clinical isolates
Strategies for Control of *E. coli* O157:H7: The multiple hurdle approach
Cattle Farm Management and Husbandry Effects

Similar prevalence of detection of E. coli O157:H7 across widely different management systems!
Pre-harvest control of *E. coli* O157:H7

- Manure management
- Watertrough and feedbunk management
- Feed components
- Probiotics / DFM
- Vaccination

Summertime peak: 50-100% prevalence

~2 million positive cattle slaughtered / month
Post-harvest control of *E. coli* O157:H7

- Animals carry *E. coli* O157:H7 with them to the beef processing plants, both by GIT and hides
- *E. coli* O157:H7 is transferred to the carcass surface by either direct contact with contaminated hides or feces, or by aerosols (primarily from hides)
- For speed and accuracy, non-pathogenic bacteria (APC and Enterobacteriaceae) are used to monitor processes

*Koohmaraie et al., 2005; Nou et al. 2003*
Because of its public health significance, the vast scientific evidence showing the high incidence in cattle, the severity of the illness, and outbreaks due to this pathogen, these events prompted FSIS (1994) to declare *E. coli* O157:H7 as an adulterant in meat (beef) products.


An adulterant:
“*any poisonous or deleterious substance which may render it (a food product) injurious to health...*”

Declaration of adulterant status had major effects on beef production facilities:
1) Installation of sophisticated complex facilities for haircoat and carcass treatment
2) Risk of recalls for products testing positive
Post-harvest control of *E. coli* O157:H7

- **Hide/hair treatments**
  - Chemical de-hairing
  - Cetylpyridinium chloride, phosphoric acid, chloroform, sodium hydroxide, ozonated water, acid chloride rinses

- **Carcass treatments**
  - Steam vacuuming
  - Organic acids / hot water
  - Steam pasteurization
  - Low dose radiation

Post-harvest control of *E. coli* O157:H7

- Process improvements
  - Carcass spacing
  - Improved lighting
  - Knife rotation
  - Improved cooling
- Test and hold procedures
  - Greatly improves response to recalls
FSIS detection of *E. coli* O157:H7 in routine testing of ground beef
FSIS detection of *E. coli* O157:H7 in ground beef and *Salmonella* in ground chicken
Detection of *E. coli* O157:H7 Triggers Food Recalls

- *E. coli* O157:H7 is considered an ‘adulterant’
  - 2009 – 2010: 25 recalls

- Microbiologic sampling: 19 recalls
  - Average size: 15,572 lbs
  - Average recall success: 51.2%
  - Recalled, but not acquired: 138,572 lbs

- Illness traceback: 6 recalls
  - Average size: 389,395 lbs
  - Average recall success: 27.4%
  - Recalled, but not acquired: 1,792,817 lbs
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<thead>
<tr>
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<tbody>
<tr>
<td>Heart disease</td>
<td>652,486</td>
<td>1 in 5</td>
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<tr>
<td>Cancer</td>
<td>553,888</td>
<td>1 in 7</td>
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<tr>
<td>Stroke</td>
<td>150,074</td>
<td>1 in 23</td>
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<td>Hospital-acquired Infections</td>
<td>99,000</td>
<td>1 in 38</td>
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<td>Car accidents (2009)</td>
<td>44,757</td>
<td>1 in 100</td>
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<td>Suicide (2009)</td>
<td>31,484</td>
<td>1 in 121</td>
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<tr>
<td>MRSA (resistant bacteria)</td>
<td>19,000</td>
<td>1 in 197</td>
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<tr>
<td>Drowning</td>
<td>3,306</td>
<td>1 in 4,919</td>
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<tr>
<td>Non-typhoidal <em>Salmonella</em></td>
<td>378</td>
<td>1 in 9,915</td>
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<td>Sun/heat exposure</td>
<td>273</td>
<td>1 in 13,729</td>
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<td>Lightning</td>
<td>47</td>
<td>1 in 83,930</td>
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<tr>
<td><em>Escherichia coli</em> O157:H7</td>
<td>20</td>
<td>1 in 187,403</td>
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<tr>
<td>Fireworks</td>
<td>11</td>
<td>1 in 340,733</td>
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<tr>
<td>Shark attack</td>
<td>1</td>
<td>1 in 3,748,067</td>
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<tr>
<td><em>Escherichia coli</em> non-O157</td>
<td>0-1</td>
<td>≤1 in 3,748,067</td>
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National Safety Council data; [http://www.flnmh.ufl.edu/](http://www.flnmh.ufl.edu/); CDC
Summary

• *E. coli* O157:H7 – a multi-faceted problem
• No effective controls in animal reservoirs
• No current prospect of an *E. coli* O157:H7-free food supply or environment
  ▪ How much should society spend on this problem?
  ▪ How safe is safe enough?
Questions?