Improving Foodborne Disease Prevention: the Ecological Connection

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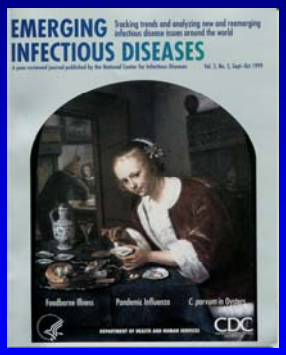
Food-related illness and death in the United States



76 million illnesses
323,000 hospitalizations
5,000 deaths

Baseline for 2010 targets:
50% reduction in specific diseases

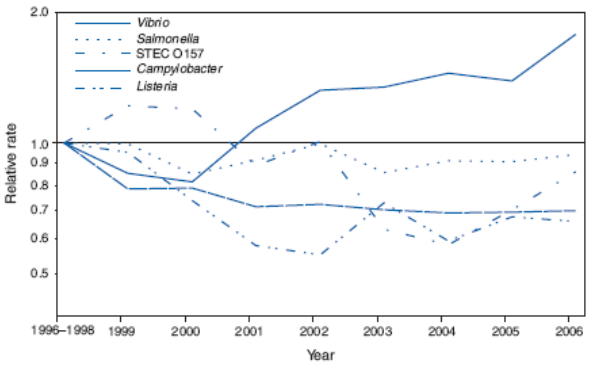
Mead et al., EID 5:707-25, 1999

Foodborne disease - 2007
Public health surveillance: FoodNet

- **FoodNet: The sentinel site surveillance system for foodborne diseases.**
  - **Active surveillance - contact all labs in area**
  - **Diagnoses of major foodborne infections**
  - **Survey population for illness and exposures**
  - **Provides our best data on burden of illness, trends**
  - **Useful information for risk assessment**
- **10 state health departments, CDC/USDA/FDA**

FoodNet trends 1996-2006

FIGURE 1. Relative rates compared with 1996–1998 baseline period of laboratory-diagnosed cases of infection with *Campylobacter*, STEC* O157, *Listeria*, *Salmonella*, and *Vibrio*, by year — Foodborne Diseases Active Surveillance Network, United States, 1996–2006



* Shiga toxin-producing *Escherichia coli*.

MMWR 2007; 56:336-339 (April 13, 2007)

Since 1996-98 baseline,

Significant change in:
***Vibrio* + 78%**
***Campylobacter* - 30%**
***Listeria* - 34%**

Insignificant change in:
***E. coli* O157**
Salmonella

None have reached HP2010 targets

Improving prevention of foodborne diseases

- Major effort to improve prevention at level of slaughter and further processing (particularly of meat and poultry)
- More pre-harvest interventions needed
  - Growing importance of produce
  - Continuing importance of animal reservoirs
  - Ecological linkages between the two
- More in-plant prevention needed for processed foods to prevent industrial contamination events
  - HACCP-like food safety programs
  - Environmental monitoring and control processes
- Need for multi-disciplinary collaboration to research these issues and develop better prevention strategies

Major multistate foodborne outbreaks, 2006-2007

- Botulism:
  - Commercial chili sauce: 8 cases in three states (biggest canned food outbreak since before 1950)
  - Pasteurized carrot juice: 6 cases in two countries. Product still sold without modification, but is inherently unsafe if unrefrigerated
- Four large outbreaks of *E. coli* O157:H7 infections:
  - Ground beef: 3 PFGE patterns, 28 cases, 8 states
  - Fresh bagged baby spinach from CA: 205 cases
  - Shredded lettuce at Taco Chain A: 77 cases, 5 states
  - Shredded lettuce at Taco Chain B: 36 cases, 2 states

(Preliminary information)

Major multistate foodborne outbreaks, 2006-2007

***Salmonella*:**

- Two large outbreaks from fresh tomatoes in 2006
  - *S.* Typhimurium: 189 cases, 21 states
  - *S.* Newport: 115 cases, 20 states
    - (same source as 2x before?)

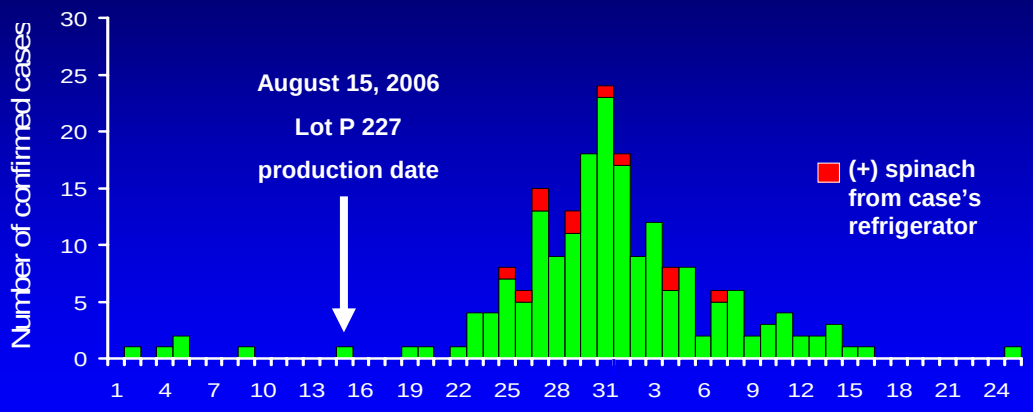
- *S.* Tennessee: peanut butter from Georgia
  - 714 cases, 48 states
  - 71 countries imported it
  - in plant contamination
  - recall of all product since 2004

- *S.* Wandsworth: Veggie Booty: 69 cases, 23 states
- *S.* Schwarzengrund: Dry dog food: 66 cases, 18 states

(Preliminary information)

CDC

E. coli O157:H7 infections and fresh baby spinach: 205 cases, 3 deaths, United States, 2006



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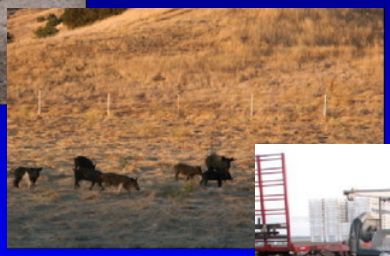
E. coli O157:H7 and baby spinach



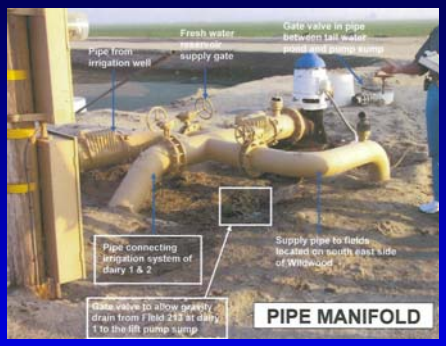
Traceback to four farms
One farm environment had
outbreak strain of *E. coli* O157
Beef cattle, stream, wild pigs, soil

Cattle 0.5 mile from field
? Spring flooding into irrigation wells
? Wild pigs traversing spinach fields

http://www.dhs.ca.gov/ps/fdb/

E. coli O157:H7 and shredded lettuce

2006 outbreak: 36 cases, 2 states
Taco Chain Y
Shredded lettuce from California farm



Fields adjacent to two dairy farms

10 samples with outbreak strain of O157
- from both dairies
- from three fields

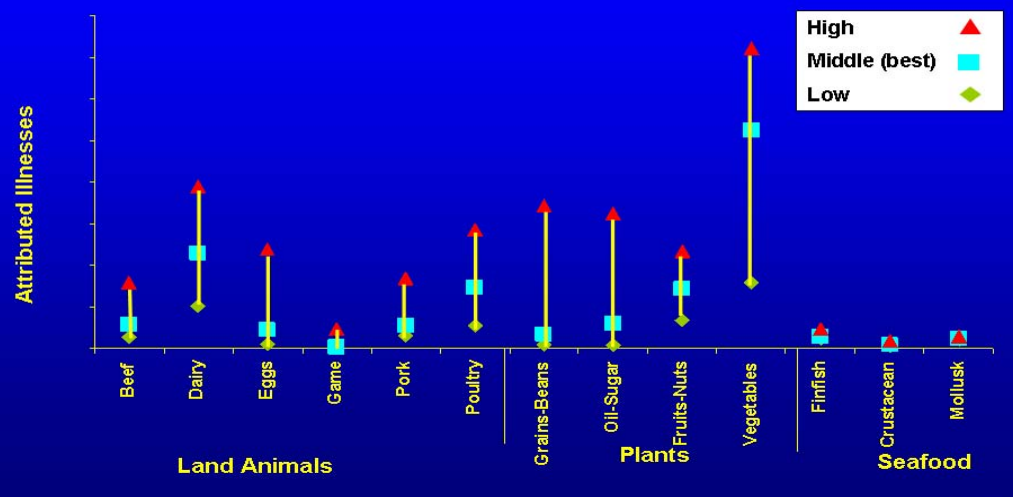
Pipes between lagoons and irrigation system

http://www.dhs.ca.gov/ps/fdb/

Improving prevention of foodborne diseases: General food production ecology

- Buffer zones between animal production and produce fields?
- Risk of water cross-connections?
- Importance of feral animal reservoirs or vectors?
- Cycling between ruminants and forage crops?
- Impact of simple environmental intervention strategies?
- Multi-disciplinary issues, need multi-disciplinary collaborative research

Estimates of illnesses attributed to food commodities, 1998-2004



Preliminary data, relationship among commodities may change

Foodborne outbreaks related to produce, 1998-2004*: Food vehicles implicated in 384 outbreaks

- Generic or mixed: 216 outbreaks
- One specific food: 168 outbreaks
  - Lettuce: 29
  - Sprouts: 20
  - Tomatoes : 11
  - Melons 11
  - Juice 8
  - Berries 7
  - Green onions: 4
  - Other produce items: 78

*eFORS, preliminary analysis and subject to change

Foodborne outbreaks related to produce 1998-2004*: Reported etiologies in 190 (49%) of 384 outbreaks

- Bacterial: 97
  - *Salmonella* 53
  - *E. coli* O157 19
  - *Shigella* 6
  - *Campylobacter* 6
  - Other 13

→ Pathogens with animal and human reservoirs

- Viral: 81
  - Calicivirus/Norovirus 73
  - Hepatitis A 8

→ Increased availability of Norovirus diagnostic testing

- Parasitic: 6
  - Cyclospora 5
  - Other 1
- Chemical: 6

*eFORS, preliminary analysis and subject to change

Improving prevention of foodborne diseases
Better pre-harvest interventions for produce

- *E. coli* (STEC), *Salmonella*, *Campylobacter*, other pathogens
- Fresh produce a growing fraction of all foodborne outbreaks
- Few opportunities for intervention after harvest
- Surprising interactions between enteric pathogens and plants
- Better understanding may enhance prevention

Internalization via irrigation

- Irrigate mature lettuce plants with water with *E. coli* O157:H7 was followed by detection of the *E. coli* throughout leaves, stems and roots (10^2-10^3/gram).
- Irrigate young tomato plants with mix of *Salmonella* of 5 serovars: Montevideo and Michigan were rapidly absorbed into above ground plant tissues, reaching 10^3 - 10^4/gram. Other serotypes not taken up
- Can other bacteria in soil block this uptake?

Solomon. J Food Protection 2005;68:870-873
Guo. Appl Env Microbiol 2002;68:3639-43
Johannessen. Appl Env Microbiol 2005;71:2221-5

Internalization via the flower

- Young tomato plants in flower
- Open flowers brushed with 5 serovars of *Salmonella*
- Tomatoes picked when red ripe
- Surface disinfected, contents of tomato cultured
- *Salmonella* Montevideo and Michigan found in deep tissues

- *Salmonella* may enter via pollen tube,at time of fertilization, and persist in the month the new fruit ripens

Guo. Appl Env Micro 2001, 67:4760-64

- Events early in planting matter

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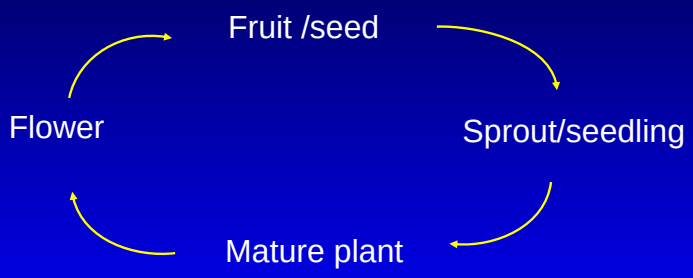
Can enteric bacteria ride the life cycle of plants?



- Pathogens can enter at each stage, and reach the next
- Shown for a variety of enteric pathogens
- Complete cycle remains to be demonstrated

CDC

Evolutionary/ecological reflections
Colonizing your host's food supply

- Enteric bacteria are often meat-associated
- Meat comes from herbivores

- Colonizing plants that herbivores eat makes evolutionary sense
- The point of edible fruit is to be eaten by a mobile herbivore, who will excrete the seeds somewhere else

- Bacteria that ride with the eaten fruit and seeds, and colonize next year's crop as it sprouts, could reach the next generation of herbivore

Improving prevention of foodborne diseases
Better pre-harvest interventions for poultry

- ***Campylobacter*** **and** ***Salmonella*** **– flock contamination affects retail product**

- ***Campylobacter,*** **in Denmark:**
  - **In lab: flies can get Campy from water, and contaminate clean water**
  - **In field: Fly screens on chicken houses reduced flock contamination 70%**

- ***Salmonella,*** **recent studies by ARS in lab:**
  - **Flies near chickens with** ***Salmonella*** **Enteritidis easily infected**
  - **Chickens eating infected flies get** ***Salmonella***

- **Research questions:**
  - **Other serotypes?**
  - **Impact of screening?**
  - **Practical strategies for screening?**
  - **Chlorination of drinking water in combination with screens?**

Hald. Emerg Infect Dis 2007, http://www.cdc.gov/EID/content/13/12/1951.htm 2008
Holt. Appl Env Res 2007. 73:6030-5

Improving prevention of foodborne diseases
Better pre-harvest interventions for beef

- Shiga toxin producing *E. coli* O157:H7 and other serotypes
- O26, O111, O103, O45, O145, O121
  - 70-83% of human illness due to non-O157 STEC
- Need basic ecological investigations of these 6
  - Found in cattle, but are they adapted to ruminants?
  - Persistence and survival in manure, soil, environment?
  - Effectiveness of composting?
- Impact of forage change?
  - Increase in price of corn, use of byproducts from ethanol production
  - Higher concentration of O157 in rumen and feces

Brooks. J Infect Dis 2005, 192:1422-9 Jacobs. Appl Env Micro 2008, 74:38-43

CDC

Improving prevention of foodborne diseases
Reducing *E. coli* O157:H7 in soil

- Recurrent problem of *E. coli* O157:H7 at county fairs and petting zoos
- The bacteria remain in contaminated soil for months
  - Concern for other uses of fairgrounds
  - Source of contamination for subsequent animals
  - What are dynamics of soil persistence?
- Experimental trials to eliminate *E. coli* O157:H7 from soil are rare
- Following 2005 outbreak at a North Carolina state fair petting zoo
  - Soil treatments of the petting zoo area (lime, bleach, other disinfectants)
  - None eliminated *E. coli* O157, and lime may actually have increased counts
  - At that point, the field was plowed under
  - Limited follow up cultures negative
- Major unresolved question – can the contamination be eliminated
  - Research on a temporarily empty feedlot

CDC

Improving prevention of foodborne diseases

- Preharvest food safety research
- Complex interactions likely among food animals, produce and the environment in which they are raised or grown
- Water, wildlife likely to play supporting roles
- Practical solutions needed
- Multi-disciplinary approach

Thank you

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

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