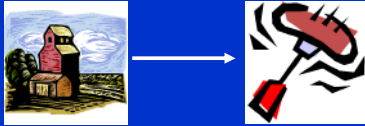


Ecology of Disease

Theme: AGRICULTURE
From Farm to Fork

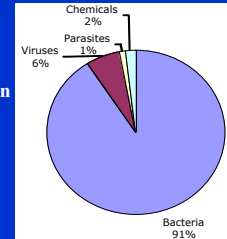


Prof Peter O'Donoghue

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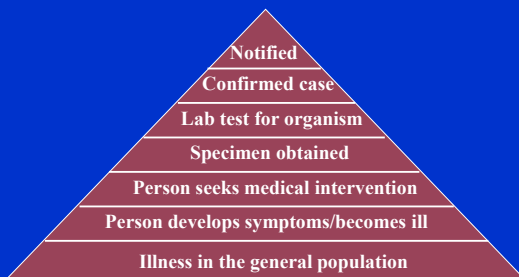
Burden of food-borne disease

- Estimated ~ 5,000 deaths annually
 - 32,000 hospitalised
- Society cost \$5.6-9.4 billion (cancer ~ \$70 billion)
 - Lost time from work ~ \$300/person
 - Medical cost ~ \$4 billion
 - Hospitalisation
 - Long term (e.g. HUS)
- Nursing homes
 - 2.4% of illnesses
 - but 20% of deaths



2

Burden of food-borne disease



3

Emerging food-borne pathogens

- Numerous aetiological agents
 - eg. *Campylobacter* sp., *Escherichia coli* O157:H7 and related *E. coli* (e.g., O111:NM, O104:H21), *Listeria monocytogenes*, Norwalk-like viruses, *Salmonella*, *Yersinia enterocolitica*
- **Virtually all have an animal reservoir (= zoonoses)**
- **Do not usually cause illness in infected animals**
 - public health concerns must now include healthy animals
 - and assess what food animals themselves eat and drink
 - contaminated foods usually look, smell, and taste normal

4

Emerging food-borne pathogens

Pathogen	Dose	Reservoir/Source	Typical Foods
<i>Campylobacter</i>	100	Poultry, cattle	Chicken, raw milk
<i>E. coli</i>	10	Cattle, sheep	Undercooked meat, vegetables, milk
<i>Salmonella</i>	Varies	Animals, Man	Meat, poultry, eggs, dairy
<i>Listeria</i>	High	Environment, Animals, Man	Cheese, milk, coleslaw

5

Emerging food-borne pathogens

Pathogen	Foodborne cases	Foodborne deaths	Annual Cost
<i>Campylobacter</i>	1.4-1.8 Million	100-500	SUS 0.6-1.0 billion
<i>E. coli</i>	8,000-16,000	160-400	SUS 0.2-0.6 billion
<i>Salmonella</i>	0.7-3.8 Million	700-3,840	SUS 0.6-3.5 billion
<i>Listeria</i>	1,512 - 1,767	378-485	?

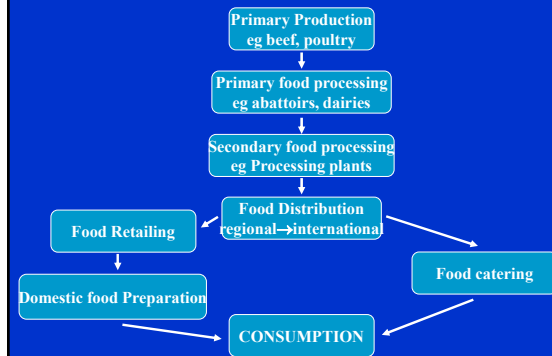
6

Emerging food-borne pathogens

- Various **ecological** questions need answering
 - Which foods transmit the infection?
 - How does the pathogen get into the food?
 - How well does the pathogen persist in the food?
 - What are the animal reservoirs (if any)?
 - How do the animals themselves become infected?
- Answering these questions leads to the development of a prevention strategy

7

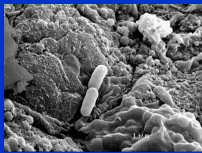
Food supply chain



8

Exemplars: food-borne gastroenteritis

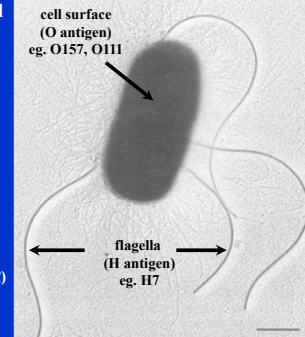
- ***E. coli* O157:H7**
 - coliform bacteria
 - toxin production
 - faecal contamination
 - esp. cattle
- ***Campylobacter***
 - enteric bacteria
 - faecal contamination
 - esp. chickens



9

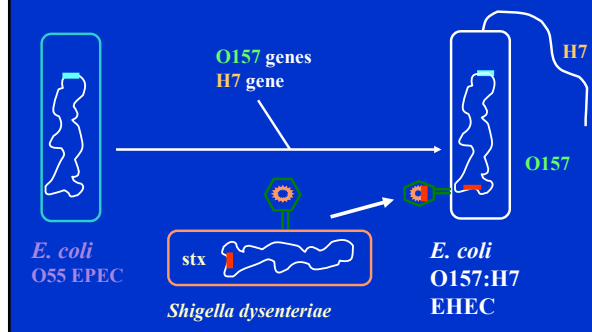
Escherichia coli

- commonly found in intestinal tract of humans/animals
- *E. coli* serotyping
 - cell surface O antigens (> 175)
 - flagella H antigens (> 50)
- most types do not cause disease
- some cause diarrhoeal disease/death
 - O157:H7
 - enterohaemorrhagic (= EHEC)
 - powerful Shiga toxin
 - flagella adhesion



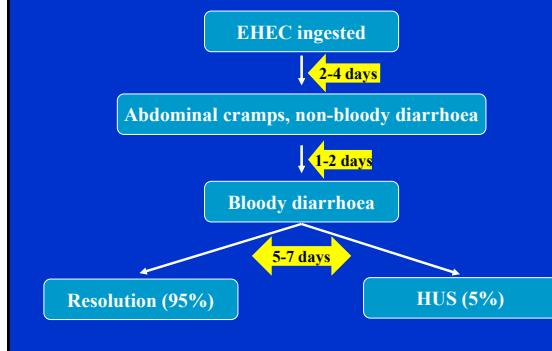
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E. coli EHEC - an emerging pathogen

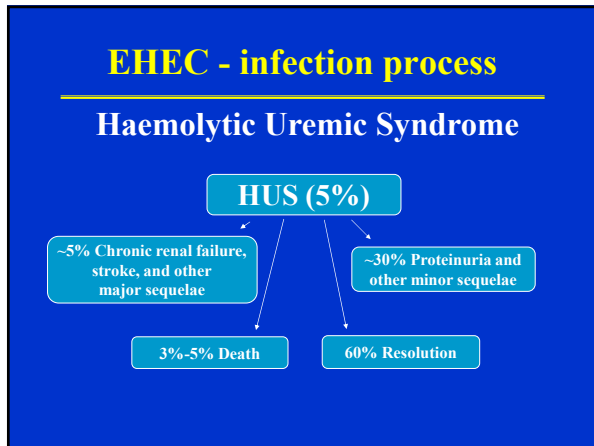


11

EHEC - infection process



12



13


- ## *E. coli* O157:H7
- CDC estimates:
 - 73,000 cases + 61 deaths due to *E. coli* O157:H7 each year in USA
 - Most infections associated with:
 - eating undercooked, contaminated ground beef
 - drinking raw milk
 - drinking contaminated water
 - Meat can become contaminated during slaughter and grinding meat distributes the bacterium even further

14

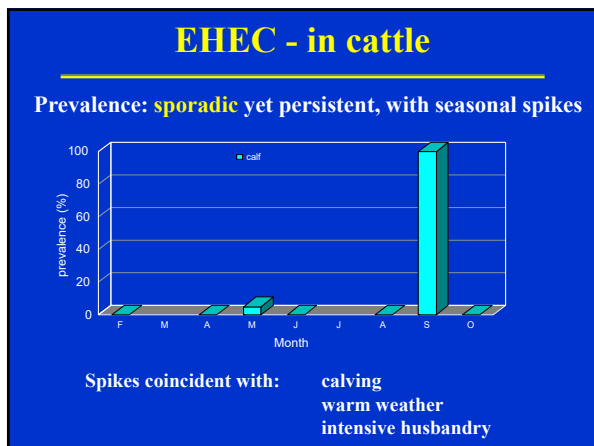
On farm sources of EHEC

Factor	Potential sources of EHEC
Animal faeces	<ul style="list-style-type: none"> ■ Faeces from dirty animals supplied to abattoirs may pass onto meat ■ Inadequately composted animal manure may spread Ec to fruit and vegetables
Slurry	<ul style="list-style-type: none"> ■ Slurry and run-off enters water supply and/or is used for vegetable production
Water	<ul style="list-style-type: none"> ■ Contaminated water used in growing fruit and vegetables ■ Contaminated water consumed by humans
Milk	<ul style="list-style-type: none"> ■ Faeces entering milk during milking
Direct contact	<ul style="list-style-type: none"> ■ Farm families and visitors handling or petting animals and not washing hands

15

- ## EHEC in cattle
- ### “Outbreaks” in cattle herds
- introduction of new animals
 - movement of cattle and other animals
 - horizontal transmission
 - direct contact
 - contaminated feed and water
 - environment
 - rainfall
 - soil and pasture
- 

16



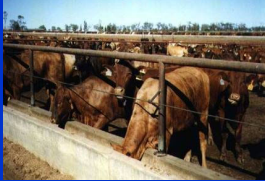
17



18

EHEC - on farm control


- Diet
 - influence bacteria
 - altering rumen pH
 - volatile fatty acids
 - starvation ↑EHEC
 - transport
 - type of food
 - supplementary hay
 - feedlot grain



19

EHEC - on farm control

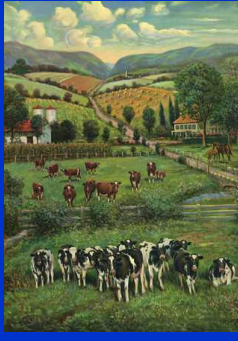
- Vaccination
 - prevent colonisation
 - target mechanism of attachment
 - but not all EHEC carry the target
 - *E. coli* O157
 - production of antibodies
 - shedding not always reduced
 - Costs & timing



20

EHEC - on farm control

- Feed additives
 - sodium chlorate
 - metabolized to sodium chlorite
 - inhibitory
 - Probiotics
 - other enteric bacteria

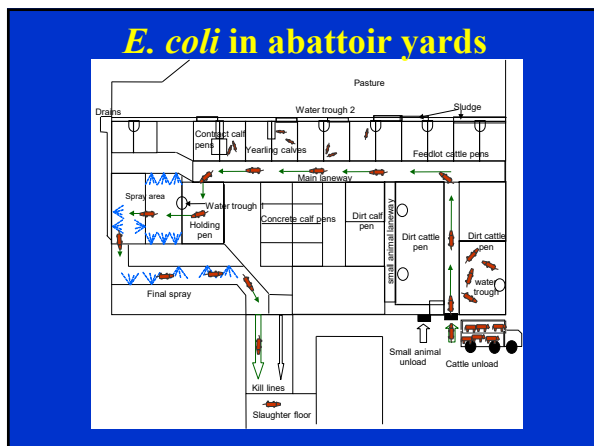


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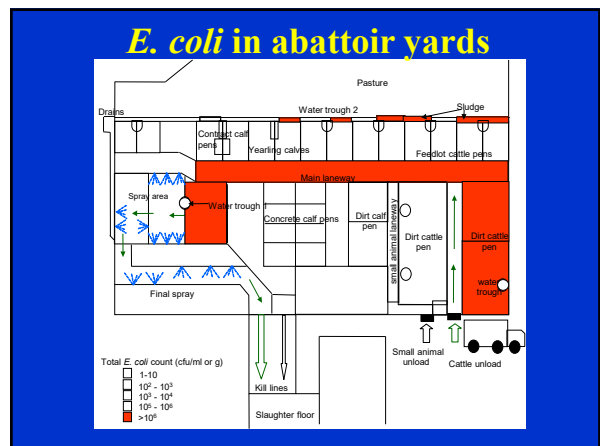
Primary processing sources of EHEC

Factor	Potential sources of EHEC
Abattoir	■ Faeces on hide of carcass
Dairy	■ Inadequate pasteurisation ■ Post-pasteurisation contamination
Packing plant	■ Washing of fruit and vegetables with contaminated water

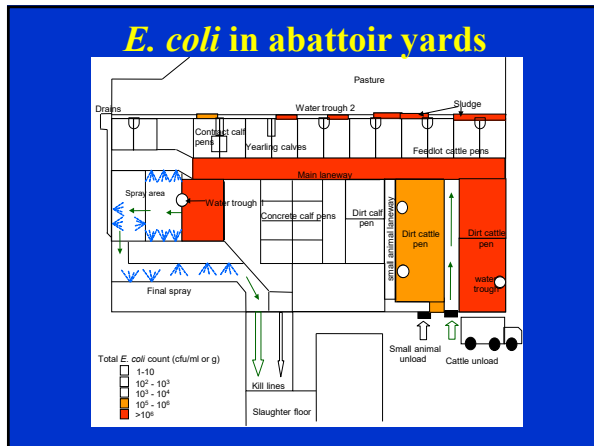
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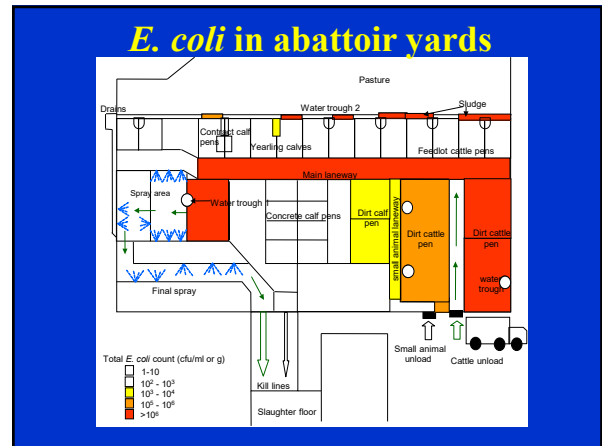
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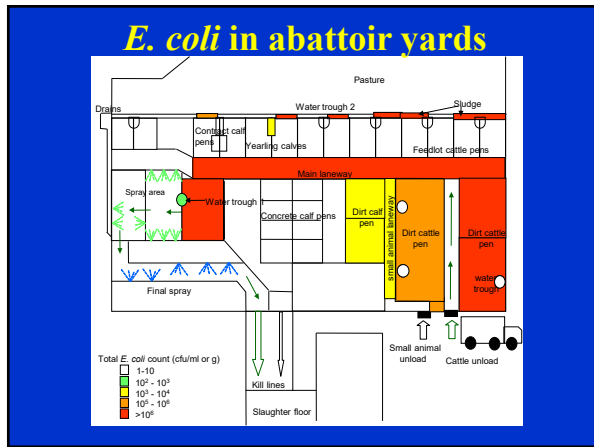
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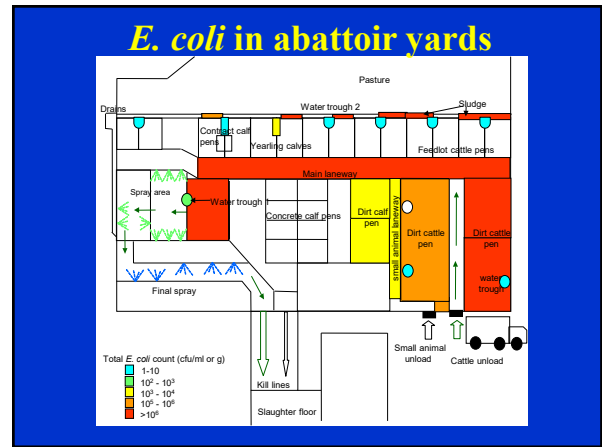
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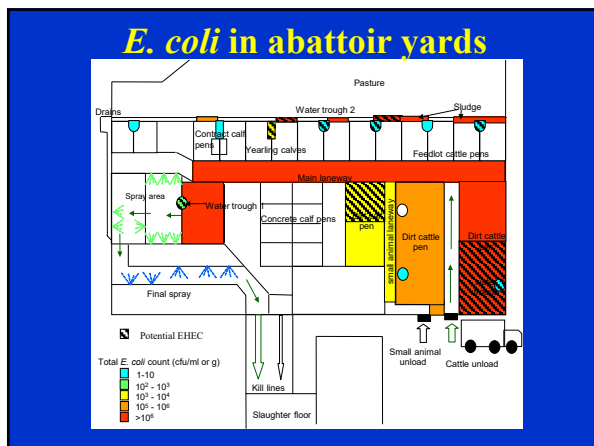
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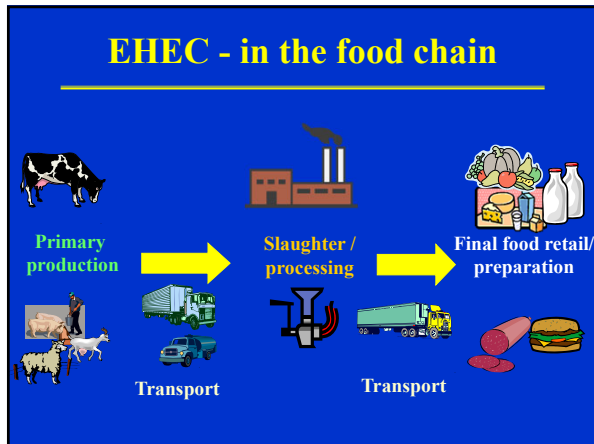


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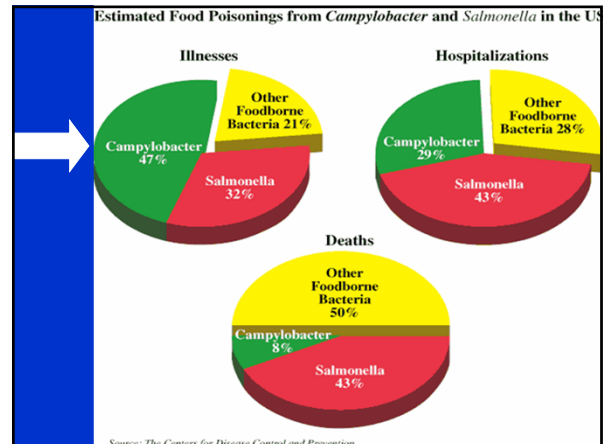
E. coli in abattoir

- Control
 - Assume all animals are potentially infected
 - Reduce risk at all stages of processing
 - ensure coats of all slaughter animals are as free as possible from faecal contamination
 - ensure that faecal contamination of carcasses does not occur at any stage of processing
 - Chill carcasses (prevent growth)

30



31



32

Campylobacteriosis

- *Campylobacter jejuni*
- ~2.4 million infections + 124 deaths each year
- commonly associated with handling/eating poultry
- also drinking unpasteurized milk
- small number organisms needed to cause infection
- chickens often show no sign of infection
- but transmit disease through
 - water supply
 - faecal contact

33

Campylobacteriosis

The diagram shows a human silhouette with labels:

- Entry:** Mouth
- Spread - occasional:** Heart and lungs
- Disease:** Nausea, Vomiting, Diarrhoea, Fever
- Exit:** Rectum

~ one in every 1000 cases leads to Guillain-Barré syndrome (inflammation/demyelination of peripheral nerves → ascending paralysis)

34

Campylobacteriosis

- Prevalence in chickens:
 - ~63% *Campylobacter*
 - ~16% *Salmonella*
 - ~8% both pathogens
- "Baseline" study, USDA
 - 88% birds infected
- Bird carcasses contaminated during slaughter
 - > 1/2 raw chicken in USA has *Campylobacter* on it

35

Campylobacteriosis

- Survival of *Campylobacter*
 - poor replication outside gut
 - grows best at 37-42°C
 - grows best in microaerophilic environment (low oxygen)
 - sensitive to freezing
 - sensitive to drying
 - sensitive to acidic conditions (pH < 5)
 - sensitive to salinity
 - BUT can survive (without multiplying)

36

Campylobacteriosis

- Intestines of poultry easily colonised
 - day-old chicks can be colonised
 - infective dose as low as 35 organisms
 - commercial operations colonised by 4 weeks
 - vertical transmission suggested but not proven
- Reservoirs in environment
 - unchlorinated drinking water
 - farm workers
 - birds
 - pests
 - feed - unlikely (too dry)

37

Campylobacteriosis

- On farm control
 - strict hygiene reduces intestinal carriage
 - birds drinking chlorinated water have fewer and lighter infections than those drinking non-chlorinated water
 - due to ease of contamination, probably impossible to completely eradicate
 - reduce susceptibility/stress?

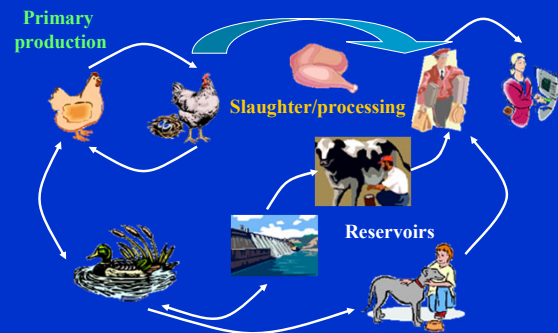
38

Campylobacteriosis

- Control at processing
 - Prevent gross carcase contamination with faeces
 - Air chilling carcasses
 - Minimise risk of environmental contamination (esp. water sources)
 - Decontaminate surfaces (chlorinated sprays)
 - Slaughter low-risk flocks first

39

Campylobacter – in the food chain



40



What's examinable?

- Food-borne diseases
 - animal reservoirs (zoonoses)
- Food supply chain
 - primary production (farm)
 - primary food processing (abattoirs)
 - secondary food processing
 - food distribution
- Faecal contaminants
 - on-farm control
 - processing plant control

41