PHR250
4/19/06, 6p

# VIRUSES AND PRIONS TRANSMITTED VIA FOOD AND WATER

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Introduction

Viruses transmitted via food and water are, with one exception, **human enteric viruses**.
Only a few primate species other than humans are infected by these viruses.
Enteric viruses infect perorally and are shed in feces.
Classification: see Table 1
Replication occurs only in susceptible cells; no DNA is involved in the replicative cycle.
Prions are a newly recognized class of infectious agents that cause fatal neurological illnesses.

Hepatitis A virus

CDC (U.S., '93–'97): 23 outbreaks, 729 cases, 0 deaths (Table 2); est. ~11,000 cases/yr
CAST: 4,800–35,000 cases/year, ≤14 deaths, $5030/case; no FoodNet coverage
Picornavirus: ca. 28 nm diameter, single (+) strand RNA; coat protein comprises 60 copies of each of four structural polypeptides; virus is relatively resistant to heat and to drying
History — Viral hepatitis recognized ca. time of World War II; fecal-oral transmission of "infectious hepatitis" (now hepatitis A) recognized much later; 5–6 hepatitis viruses now known, but only hepatitis A is known to be transmitted via food and water **in North America**
The disease
- Virus in feces of infected person
- Entry via intestines
- Liver colonized; infected cells destroyed by host's immune response; incubation 15–50 days (average 28–30); virus shed in feces 1–2 weeks before onset
- Illness: fever, malaise, anorexia, nausea, abdominal discomfort—jaundice (?); usually complete recovery after a few weeks, with permanent immunity

Transmission/Control
- Routes — person-to-person, or via water (drinking, irrigation?), "undercooked" shellfish, or food handled by an infected person
- Prevention — sanitation, cooking, **vaccination** (U.S., 1995)
- Food as a vehicle

Norwalk-like gastroenteritis viruses ➛ "Noroviruses"

CDC (U.S., '93–'97): 9 outbreaks, 1233 illnesses, 0 deaths; **est. 9.2 million foodborne/yr**
CAST: 181,000 cases/year, 0 deaths, $890/case
History and naming
- Norwalk, Ohio, gastroenteritis outbreak, 1972
- Small round structured viruses (SRSV), "Norwalk-like"
- Calicivirus group — small (~30 nm), single-stranded RNA, protein coat has

- "dimples"
- The disease — vomiting and diarrhea; less common than rotavirus in infants
  - Virus from ill or convalescent person via feces or vomitus
  - Colonization of intestines — incubation: 1–2 days
  - Severe diarrhea & vomiting — 12–60 hr (usually 24–48), virus shedding up to 7 days
  - Antibody is not protective
- Transmission/Control
  - Routes — person-to-person, or via water, "undercooked" shellfish, or food handled by an infected person
  - Prevention — sanitation, cooking
- Diagnosis
  - Virus in feces: ELISA for antigen; RT-PCR for viral nucleic acid; serogroups
  - Antibody production

Other gastroenteritis viruses
- Astroviruses — occasionally foodborne, some replicate in cell culture
- Rotaviruses — more often infant diarrhea than foodborne disease
- Adenoviruses — serotypes 40 & 41, not known to be foodborne
- Coronaviruses — questionable cause of human diarrhea, foodborne once?

Other viruses and food
- Human enteroviruses (polioviruses, coxsackieviruses, echoviruses)
- Hepatitis E virus — **water**, food?
- Tick-borne encephalitis virus — milk & milk products, Slovakia
- Industry alarms
- "Non-problems" — hepatitis B, C, & D; herpes, HIV, hantavirus

Detection & monitoring: cytopathic effects in cell culture, plaques
- Diagnosis
- Detection of viruses in food
  - Sample processing — liquefaction, clarification, concentration
  - Test methods — probes, PCR, antigen capture
- Indicators — bacteria, viruses, phages

Prevention
- Food vehicles
  - Shellfish (bivalve mollusks)
  - Other food vehicles
- Sanitation (handwashing)
- Depuration of shellfish — not very successful
- Cooking, inactivation

Prions

Transmissible spongiform encephalopathies (TSEs)
- Accumulation of abnormal prions in brain leads to spongiform degeneration
- All are fatal
- Some are “contagious”

Prions are
- Low MW peptides found in CNS & some other organs
- Normal folding (“$PrP^{C}$”) depends on amino acid sequence.
- Abnormal (various causes, “$PrP^{Sc}$”) produces a protease-resistant molecule

“Old” TSEs
- Scrapie in sheep
- Creutzfeldt-Jakob disease (CJD), sporadic, etc., in humans
- Transmissible mink encephalopathy
- Chronic wasting disease (deer, elk)

“New” TSEs
- Bovine spongiform encephalopathy (BSE) — “mad cow disease”
- Feline spongiform encephalopathy
- New variant CJD (vCJD) in humans

BSE in cattle, UK
- April 1985 to December 2004, 184,131 confirmed cases of BSE (3–5-yr incubation)
- Control by not feeding rendered bovine meat-and-bone meal (MBM) to cattle — slow enforcement
- Slaughter of affected *herds*
- Enormous research effort
- No BSE prions found in red meat (voluntary muscle) or milk
- Vertical transmission (cow-to-calf) “unlikely”
- Carcass disposal precautions

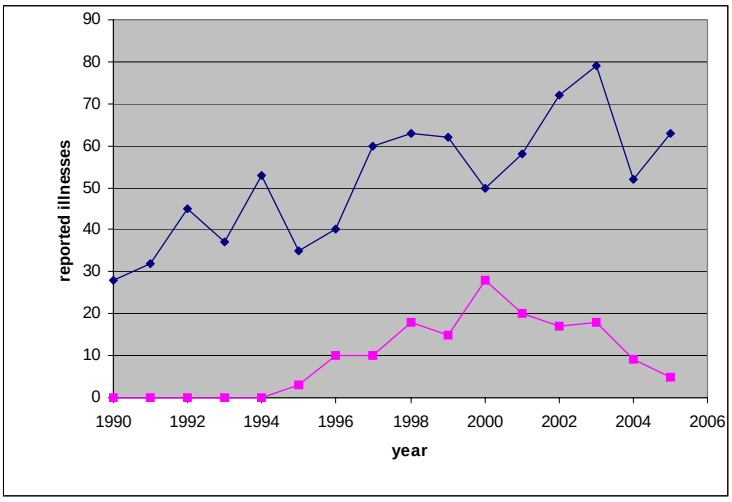
BSE in cattle elsewhere
- Some cattle, much beef, and a lot of MBM exported from UK to other countries
- Now ca. 24 countries have BSE (few thousand cases), all in Europe except Japan, Israel (occupied West Bank territories), Canada, and **US**, so far

Inter-species transmission
- Ca. 1994, TSE in cats (UK), including zoo species
- In 1995, something resembling CJD began occuring in young people in the UK — “new variant CJD” or “vCJD” (>10-yr incubation?)
- vCJD differs in more than age distribution of victims

**Impact of vCJD**

~153 people in UK, ~23 in the rest of the world affected by 12/05 (almost all deceased)
Even in UK, <CJD rate (28 vs 49 in peak year, 2000)
Far less than deaths from other foodborne diseases
HUGE public reaction
Specified bovine offals banned from the food chain, most BSE countries
Cattle >30 months old not eaten in UK, carcasses incinerated
Slaughter cattle >30 (24 in some countries) months old tested in other BSE countries
Genetic susceptibility — all vCJD patients tested have been homozygous for methionine at codon 129 of their prion gene (40% of population)
Restrictions on blood donation and use

Sporadic CJD and vCJD in the UK, 1990–2005




BSE in Canada, spring 2003

One cow, no trace
Exports to U.S. (& other countries) cut off

BSE in US (Washington), December 2003

One cow, possible “downer”
Huge interstate recall of meat
Media orgy
Embargoes on US beef

US control measures

- Ban on feeding mammalian meat and bone meal (MBM, product of rendering) to food-source ruminants
- Restrictions on blood donation
- Scrutiny of biologicals
- Slaughter of downer cattle prohibited
- Risk materials, from animals >30 months old, prohibited from human food supply
- Other prohibitions pending
- More testing of downers, dead-on-farms, and suspects at slaughter
- Major over-reaction to minimal threat to human health

Drama in North America — chronic wasting disease

- Deer & elk, Colorado, Wyoming
- Other states (*Wisconsin*), Canadian provinces, farmed and wild animals
- Environmental transmission (feces?)
- Transmissible to humans??
- Processing carcasses — food safety?
- Now upstaged by BSE

Summary

- Human enteric viruses, fecal contamination
- Cooking or other means of inactivation (depuration)
- Detection vs. indicator systems for monitoring
- Prion diseases are here in North America.
- Threat to human health is minimal.
- Measures being imposed may well lessen overall food safety.

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http://www.fda.gov/cber/bse/bse.htm (has many links)

Table 1. Major groups of human enteric viruses.

| Size (nm) | NA strands | RNA | DNA |
|---|---|---|---|
| 25–35 | single | astro-<br>calici-<br>picorna- | parvo- |
| 70–85 | double | reo-<br>rota- | adeno- |

Table 2. Causes of foodborne outbreaks, U.S., ’93–’97

| Rank | Causative agent | Cases | % |
|---|---|---|---|
| 1 | *Salmonella* spp. | 32,610 | 37.9 |
| 2 | *Escherichia coli* | 3,260 | 3.8 |
| 3 | *Clostridium perfringens* | 2,772 | 3.2 |
| 5 | Other viral | 2,104 | 2.5 |
| 7 | Norwalk-like viruses | 1,233 | 1.4 |
| 9 | Hepatitis A virus | 729 | 0.8 |