

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.
- Replication occurs only in susceptible cells; no DNA is involved in the replicative cycles of the RNA viruses.
- Prions are a newly recognized class of infectious agents that cause fatal neurological illnesses.

Major groups of human enteric viruses.

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

Causes of foodborne outbreaks, U.S., '98-'02

Rank	Agent	Cases	Percent
1	Norovirus	27,121	21.2
2	<i>Salmonella</i>	16,821	13.1
3	<i>Clostridium perfringens</i>	6,274	5.2
4	<i>Escherichia coli</i>	4,864	3.0
5	<i>Shigella</i>	3,677	2.9
6	<i>Staphylococcus aureus</i>	2,766	2.2
7	<i>Campylobacter</i>	1,440	1.1
8	Hepatitis A virus	981	0.8
9	<i>Vibrio parahaemolyticus</i>	613	0.5
10	<i>Bacillus cereus</i>	571	0.4

(from Lynch et al., 2006)

Noroviruses: Norwalk-like gastroenteritis viruses

- CDC (U.S., '98-'02): 657 outbreaks, 27,171 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

Hepatitis A virus

- CDC (U.S., '98-'02): 60 outbreaks, 981 cases, 0 deaths; 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

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. 30 countries have BSE (few thousand cases), all in Europe except Japan, Israel (occupied West Bank territories), Oman, Canada, and **US**, so far; 152 cases worldwide in 2006

Inter-species transmission

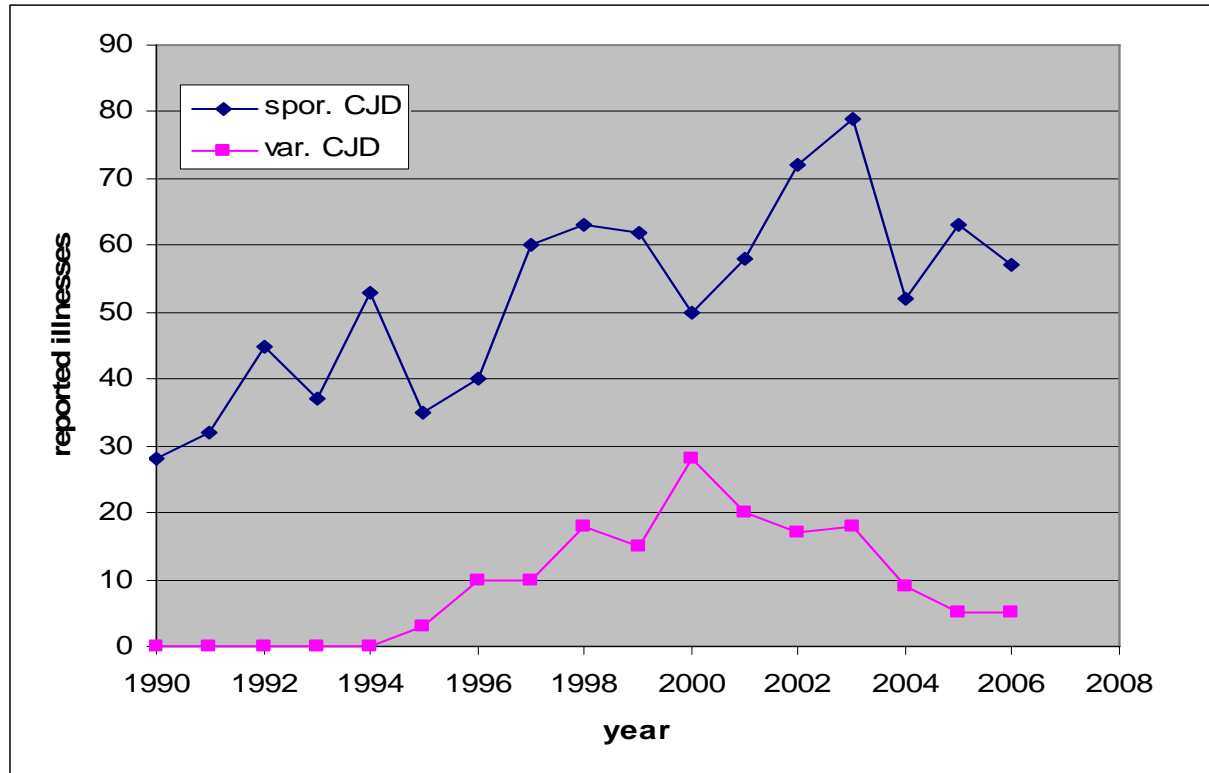
- Ca. 1994, TSE in cats (UK), including zoo species
- In 1995, something resembling CJD began occurring in young people in the UK — “new variant CJD” or “vCJD” (>10-yr incubation?)
- vCJD differs in more than age distribution of victims

Impact of vCJD

- ~165 people in UK, ~37 in the rest of the world affected by 04/07 (almost all deceased)
- Even in UK, <CJD rate (28 vs 50 in peak year, 2000; 5 vs 57 in 2006)
- 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 — discontinued, 2006
- Slaughter cattle >30 (24 in some countries) months old tested in other BSE countries
- Genetic susceptibility — all “primary” vCJD patients tested have been homozygous for methionine at codon 129 of their prion gene (40% of population)

- Restrictions on blood donation and use (3 from transfusions in UK)

Sporadic CJD and vCJD in the UK, 1990–2006



BSE in Canada, spring 2003

- One cow, no trace
- Exports to U.S. (& other countries) cut off — now largely restored
- Case total now at 9

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; case total now 3
- 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)