# Infections passed on via food and drink.


Christopher Whitty

Gresham College 2021

# Route of transmission is key to understanding and combatting infectious diseases.

- Vector-borne (insects etc).
- **Oral- food, water and other drink.**
- Sexual (& bloodborne).
- Respiratory.
- Touch.

- Usually one route dominant.
  Sometimes secondary routes.

Lucas van Valckenborch. Meat and fish market C 1595

The oral route is potentially a good one for an infection to enter the body. Multiple viruses, bacteria and parasites have evolved to use it.

- Water and food are essential.
- Does not require the person/animal doing the infecting to meet the infected person. E.g. cholera downstream, through watersource.
- Infected individuals are often infectious for prolonged periods.


Broad Street Pump

# Common patterns of infection via oral route.

- Water borne.
- Milk; drink and milk products, eggs.
- Faeco-oral between humans on food.
- Faeco-oral from animal to human on food.
- Animal and fish parasites- humans a central host.
- Animal, bird and fish. Humans an accidental host.

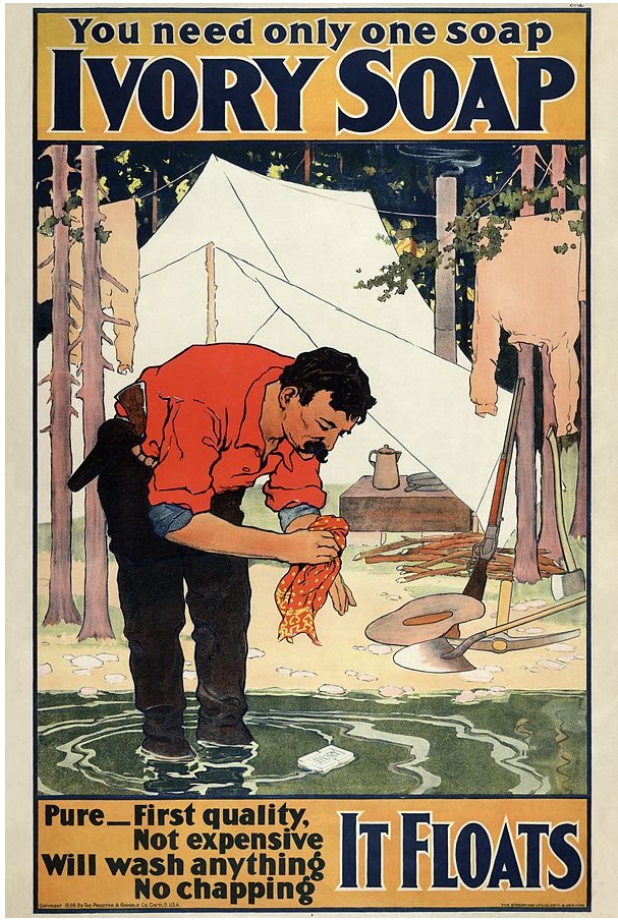
The Milkmaid. Johannes Vermeer (1658–1661).

# If you know transmission is via the oral route some clear countermeasures.

- If from humans: hygiene (esp. handwashing after defaecation), sanitation (faeces disposal, clean water), cooking/washing/boiling.

- If from animals or poultry: animal husbandry, handwashing when cooking, cooking meat, (freezing).

- If from fish: cooking (freezing).



# For the oral route of infection engineers, farmers, food handlers and cooks more important than doctors.

- Clean water technology.
- Sewers.
- Cooking and freezing technology.

- Hygienic animal husbandry.
- Identifying and isolating diseased animals.
- Maintaining a hygienic cooled food-chain.

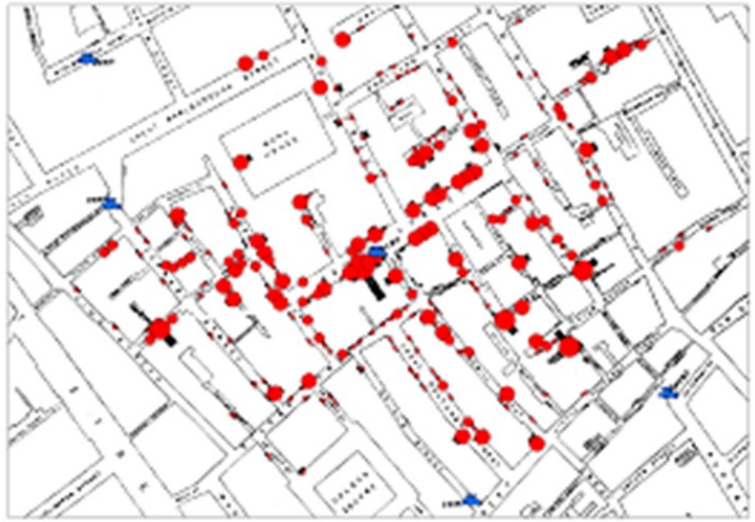
Hans Sebald Beham, 1538

# Water.

- Water borne v water washed.
- Water borne in the water you drink.
- Diarrheal diseases, cholera, typhoid, polio, cryptosporidium, giardia and others.
- Water washed- lack of water leads to reduced hygiene or sanitation.

# Cholera the archetypal epidemic waterborne disease.

- Endemic in low levels especially deltas of Indian subcontinent.
- Causes massive diarrhoea.
- Seven major pandemics, first started 1817, 7th started 1961 ongoing. 10s of millions killed.
- In 1854 London epidemic mortality rates up to 12% seen.
- Snow mapped cases onto certain water companies, and famously  the Broad Street pump.

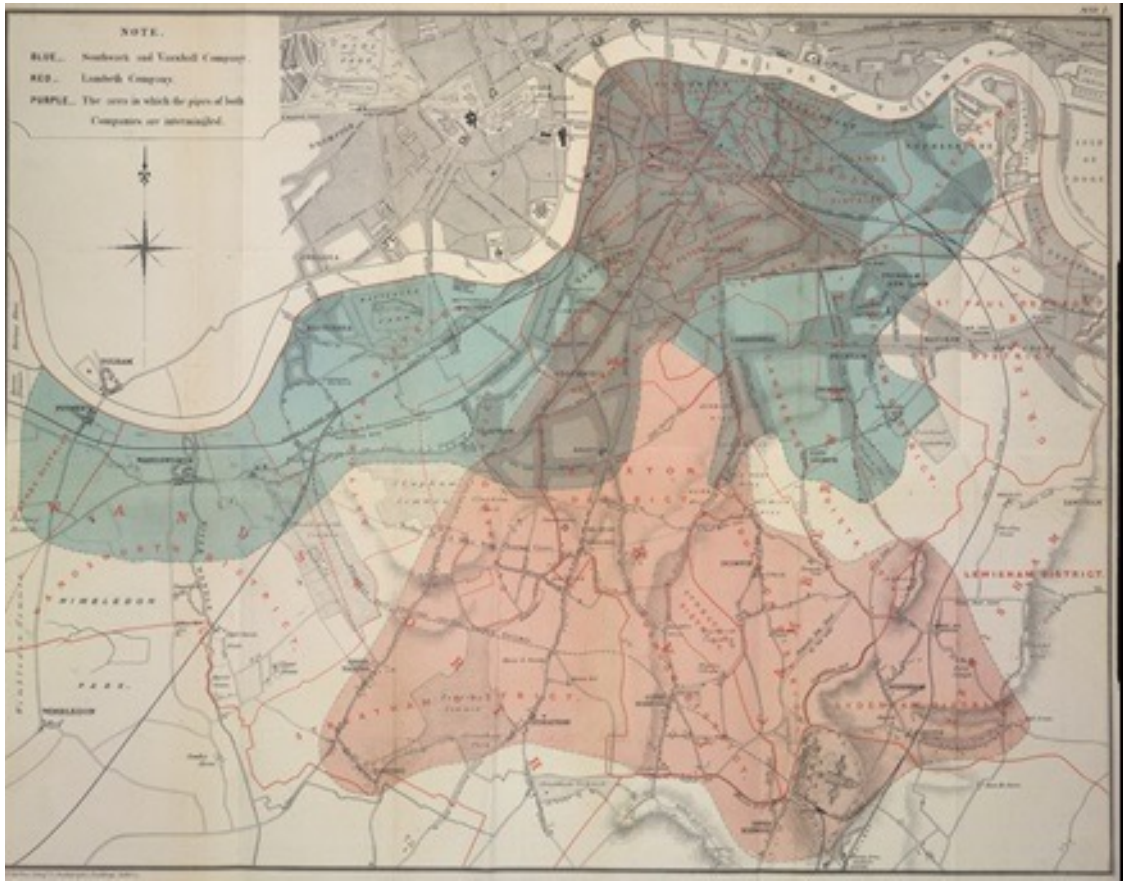


*R. Wilson augmented John Snow's original map of 1854*

# John Snow's demonstration that cholera was caused by contaminated water a turning point.

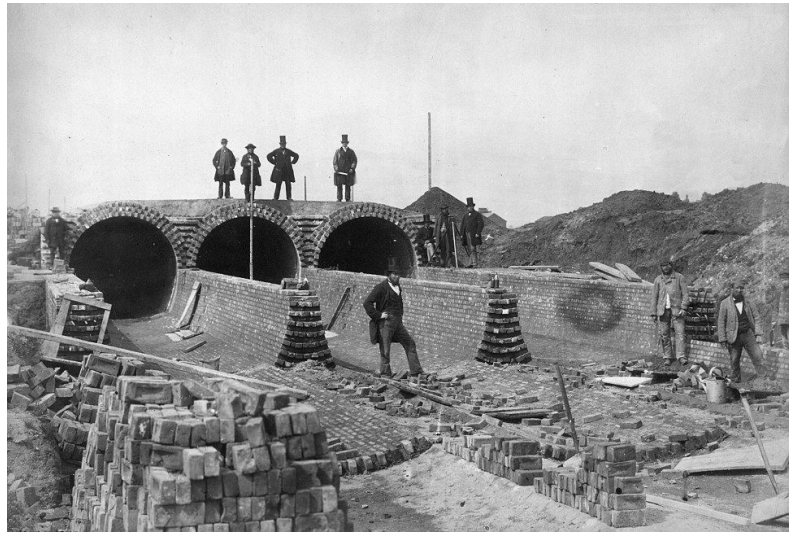
- He showed that cholera mapped onto particular water companies.

- The Lambeth Company 5 deaths per 1000 households. Southwark & Vauxhall Company (blue) 71/1000.



# The key to combatting waterborne diseases is engineering.

- Need to separate human faeces from water.
- Provision of sufficient sewerage and sewage treatment.
- Better sourcing of water.
- Water treatment for remaining pathogens.
- Waterborne infections now rare in high-income settings.



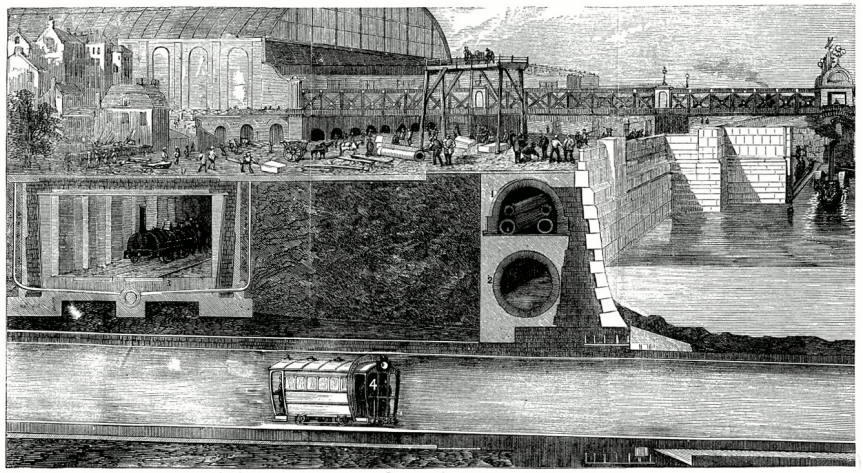
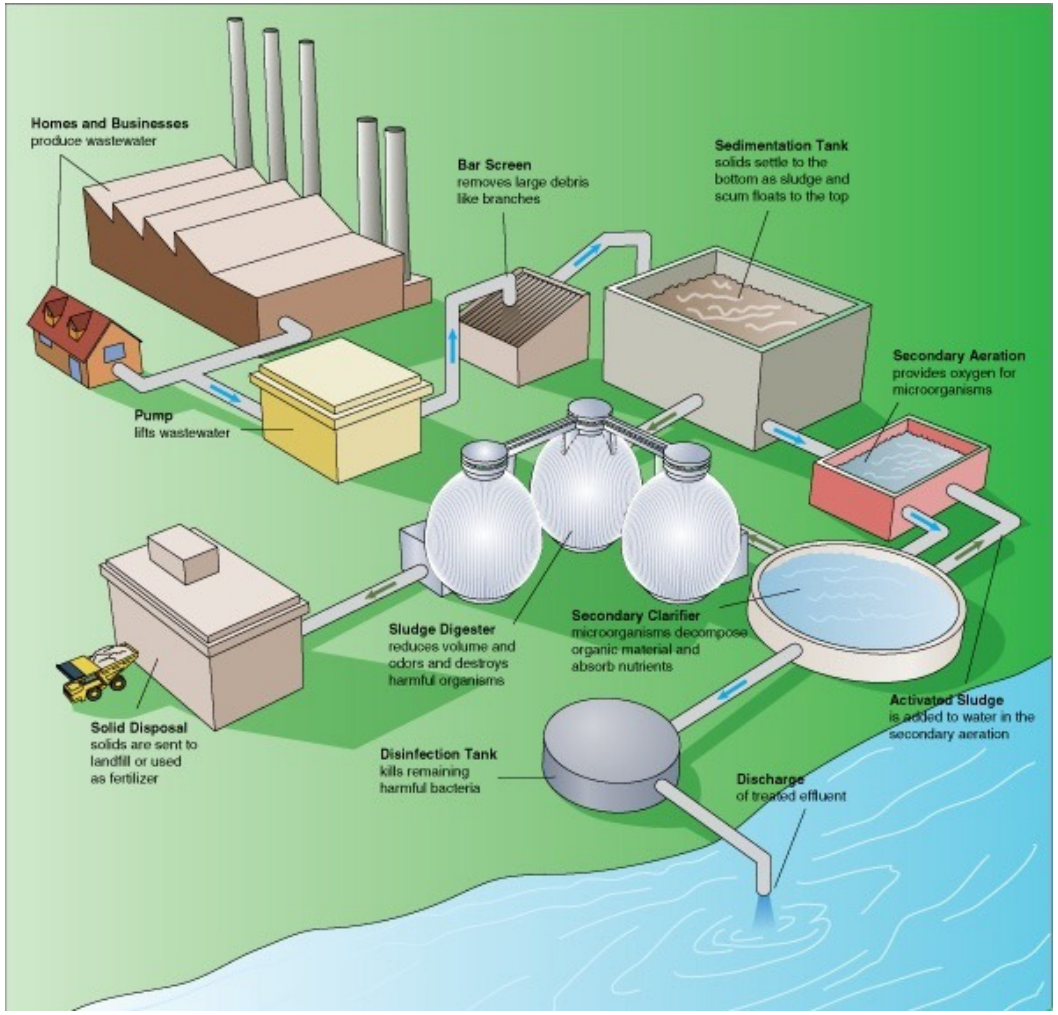


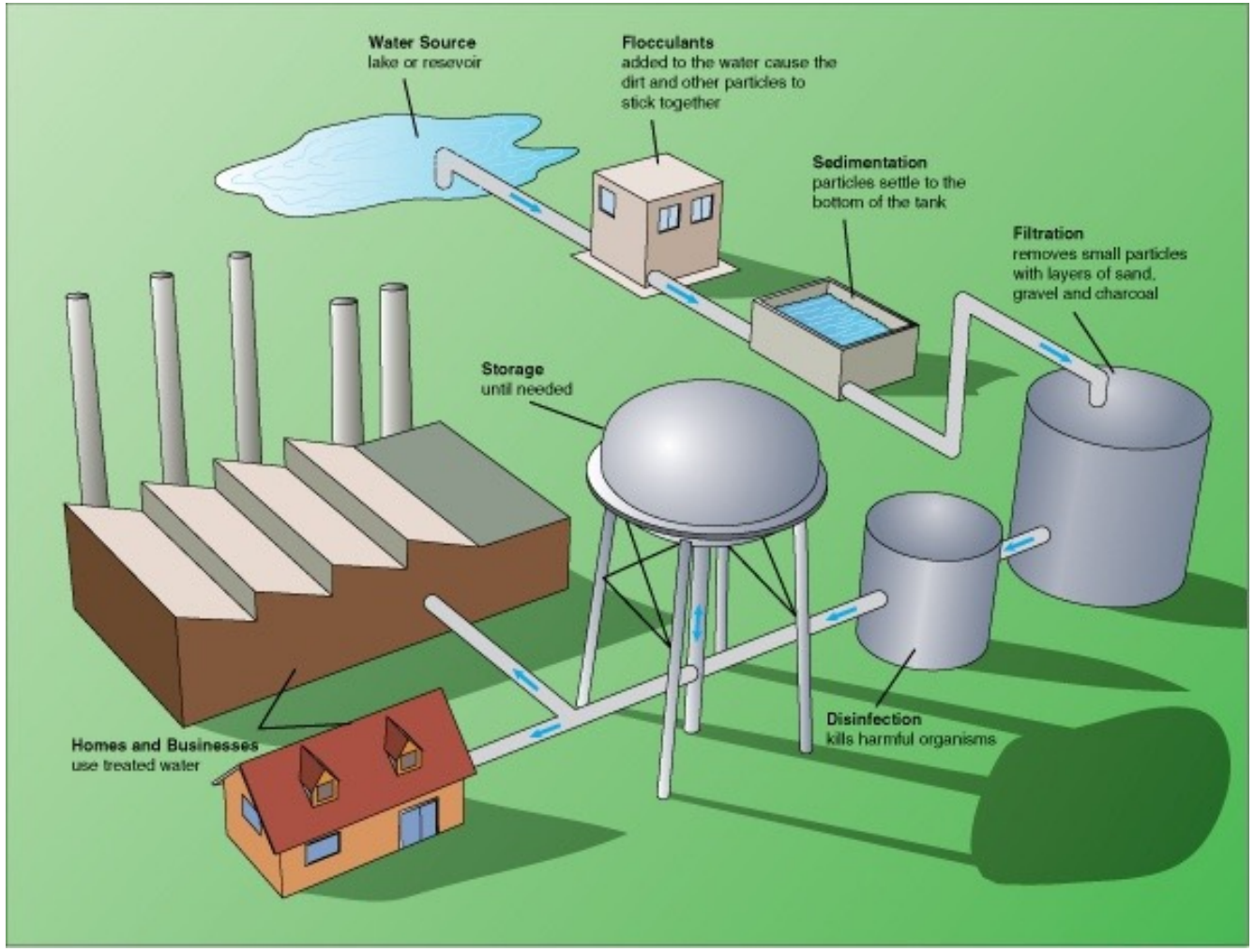
*Fig. 6.—Section of the Pneumatic Passenger Railway under the Thames River, London.*

(1.) Subway for Gas and Water Pipes. (2.) Sewer. (3.) Metropolitan Underground Steam Railway, now in course of construction. The Pneumatic Railway extends from Charing Cross, and passes under the Thames River to the Waterloo Road Station of the Southwestern Railway. The engraving represents that portion under the Thames embankment which has been finished.

Joseph Bazalgette and the building of London sewers.

# Sewage treatment (L), water purification (R).




CK-12 foundation.

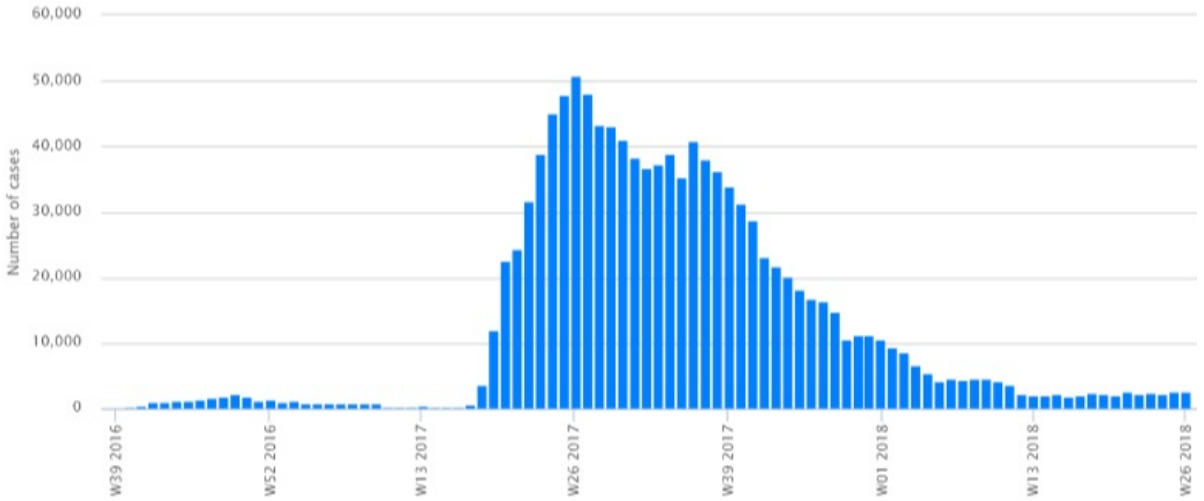
# Water-borne diseases in retreat but remain a major threat in areas of poverty.

- WHO estimates that around 70% of people have access to uncontaminated on-premises drinking water.
- But at least 2 Bn use water contaminated with faeces.
- This causes substantial numbers of deaths.
- Surface water most risky.
- It is possible to make contaminated water safe to drink by some combination of boiling, filtering and chemicals (eg iodine) but at a cost.


AusAID/Jim Holmes

When infrastructure breaks down due to war or disaster, cholera and other diarrhoeal diseases follow.

- Cholera still affects an estimated 3–5 million people worldwide, and causes 58,000–130,000 deaths.
- Down from an estimated 3 million deaths a year early 1980s.
- Recent outbreaks include Yemen, Zimbabwe, Haiti, Mozambique.




Cholera cases by week, Yemen, 2017-19.

# Vegetables can harbour human or animal faecal contamination leading to infection.

- Vegetables in some settings  fertilised with ‘night soil’.
- Animal manure a common fertiliser in lower-income settings.

- If people have not washed their hands between defecation and preparing food high levels of faecal contamination possible.

- ‘Cook it, wash it, peel it or leave it’.

# Examples where human faeces on food can lead to human infection.

- Typhoid (enteric fever)- a major global killer in previous era, still a major disease in low-income settings. Can also be waterborne.
- Bacterial and viral diarrhoeal diseases. Cause substantial mortality in children.
- *E. coli* travellers diarrhoea.
- Polio.
- Giardia parasites.
- Several intestinal worms.

CDC

# Duration of infectiousness varies by infection.

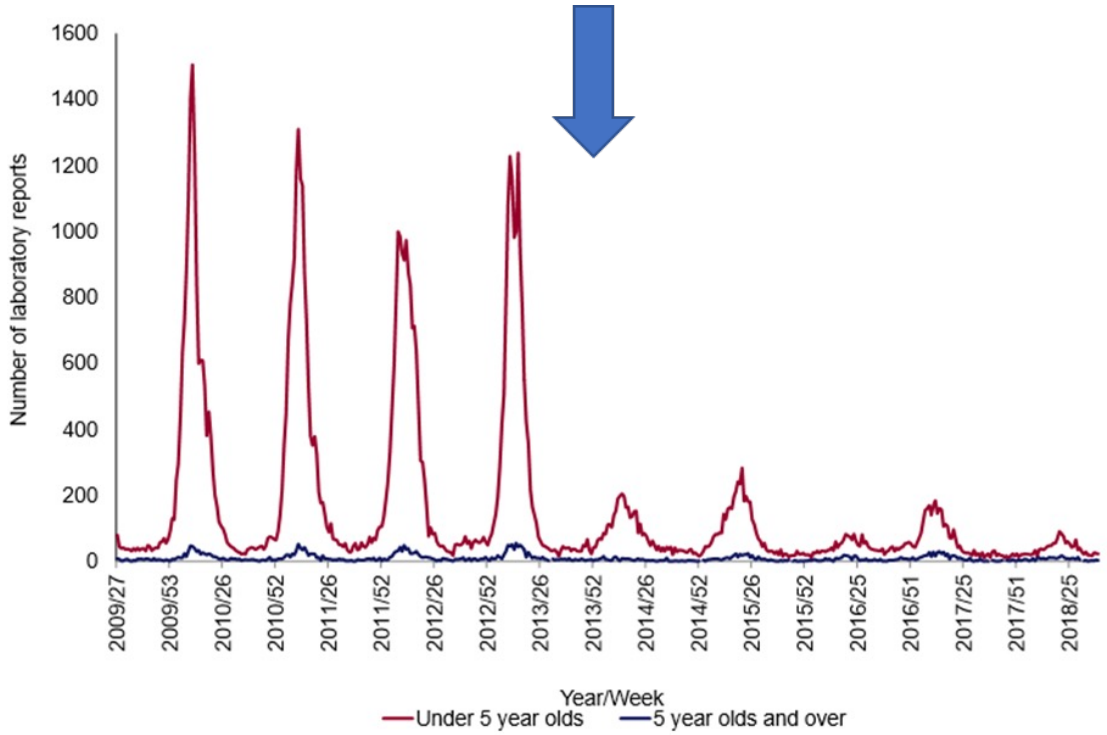
- Some faeco-oral infections are infectious only for a short period. Includes many of the diarrhoeal diseases.
- Some people can be chronic (long-lived) shedders of infection even if they are well.
- Risk is lack of hand washing and uncooked food preparation.
- Several parasites, typhoid examples.
- Treatment can stop infectiousness of most (not all).
- Used to lead to draconian incarceration in some states. Mary Mallon an example of someone who spent almost 30 years in forcible quarantine.

Mary Mallon, 1909.

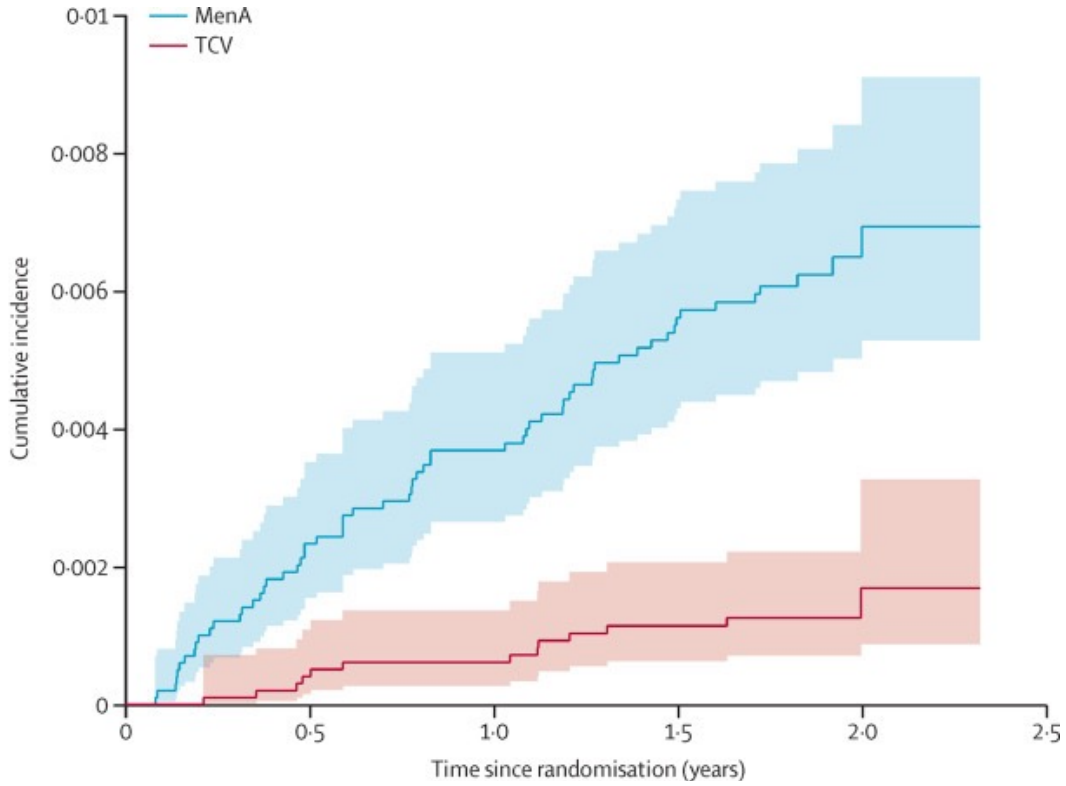
# For some of the major diseases we now have vaccines.

## When handwashing is not enough…

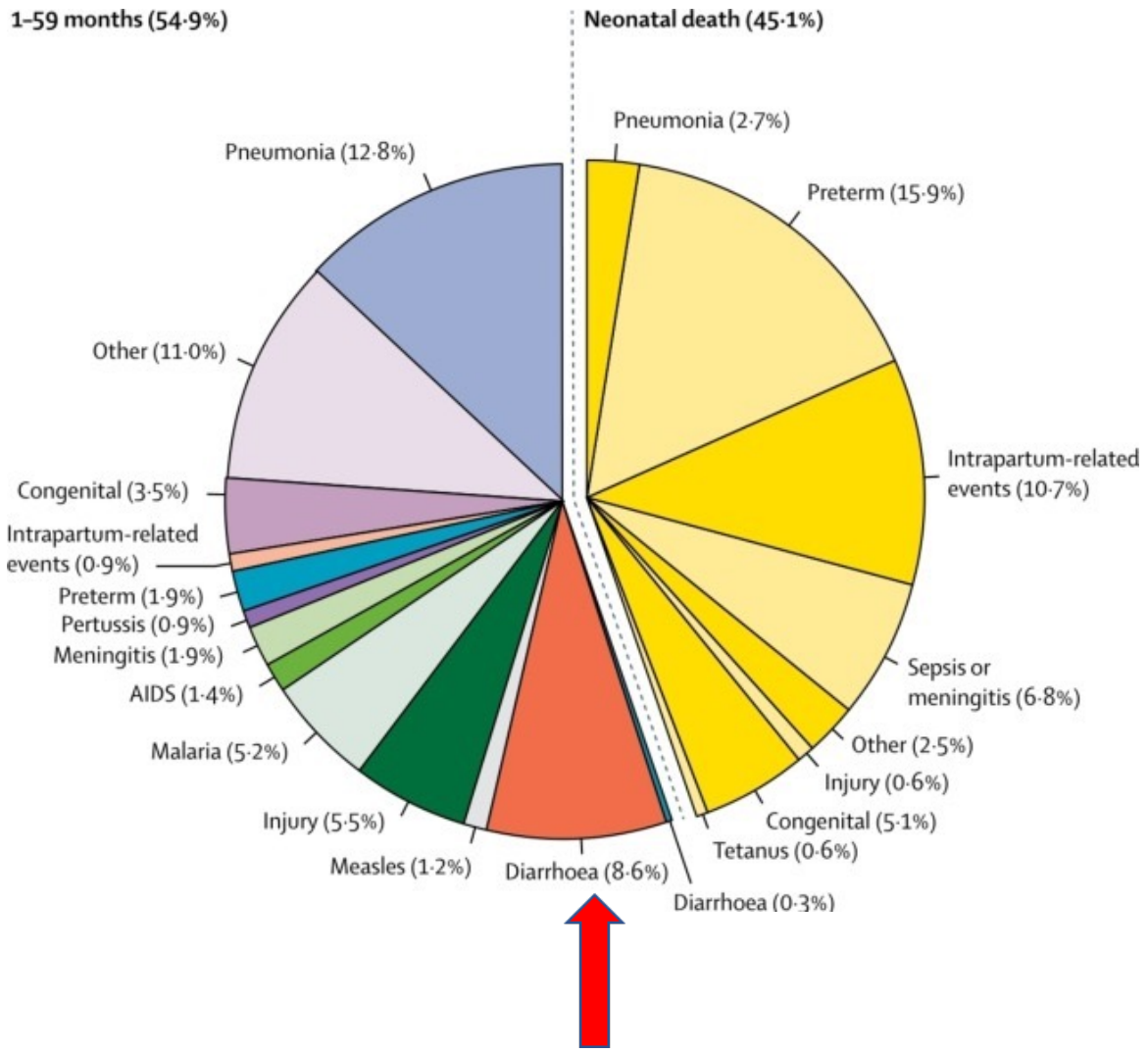
**Rotavirus in England and Wales 2009-18. PHE**




**Typhoid vaccine in Nepal. 79% protection. Shakya et al 2021**



# Diarrhoeal diseases are major causes of mortality in children. 8.6% of global deaths <5 years. Around 500,000 a year (<20 UK).

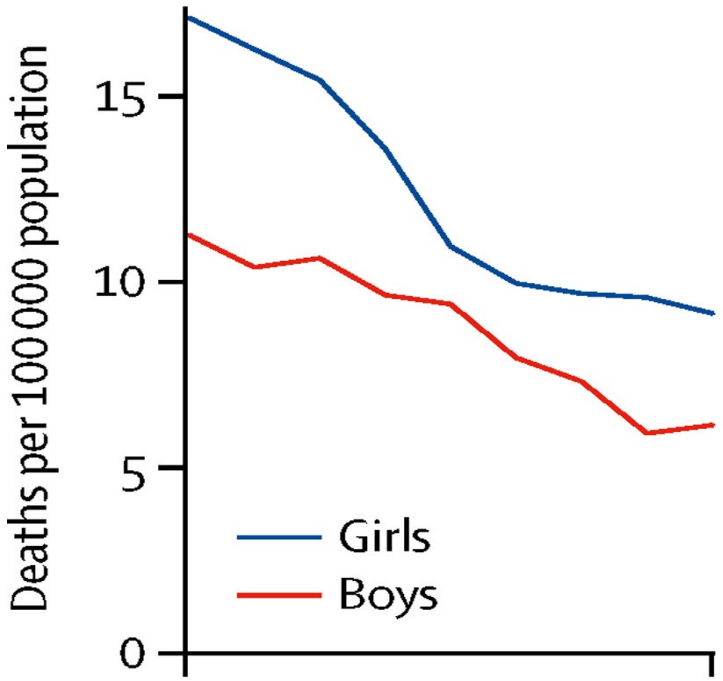



Liu et al, Lancet 2016.

# Deaths from infectious diarrhoea and enteric fever in children of all ages are falling rapidly almost everywhere.

The combined effects of:

- Sanitation
- Clean water
- Soap
- Oral rehydration solution
- Less malnutrition
- (Antibiotics)
- Rotavirus vaccine.




Diarrhoea deaths in children 5-14, India 2005-15. *Fadel S et al Lancet 2019*

# Ingested toxins from skin bacteria can case diarrhoea and vomiting even if the bacteria not present.

- Staphylococcal enteritis- a toxin.
- From skin contamination.
- Explosive diarrhoea 1-6 hours after ingesting.
- Mass-produced cream-filled baked goods, poultry, gravies, eggs, meat salads, puddings and vegetables.

*Dennis Sylvester Hurd/wiki*

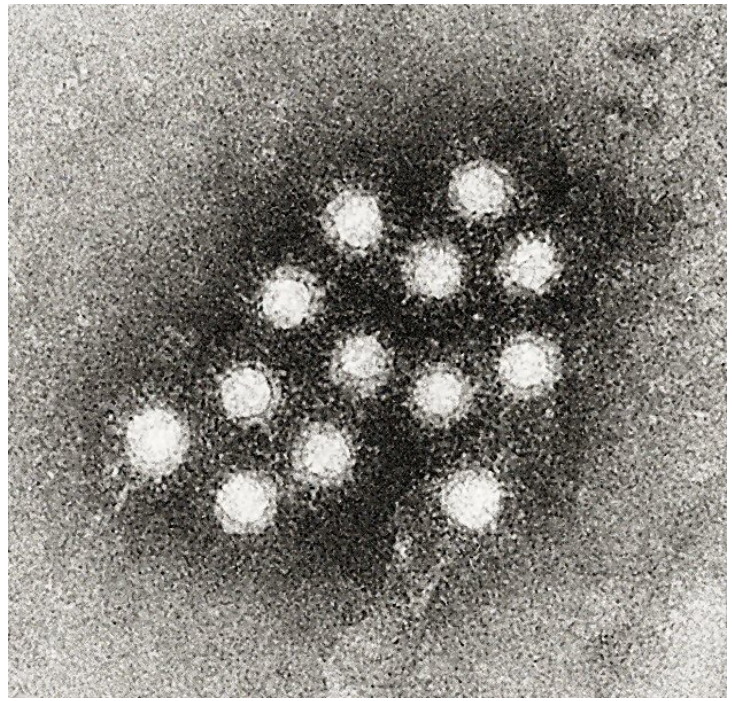
- Washing hands before preparation….

# Pinworm has evolved a way around normal hygiene.

- *Enterobius vermicularis* (pinworm, threadworm).
- Lays eggs around anus. Very itchy.
- Uses the natural urge to scratch an itch.
- And of children to touch one another.
- And parents to show affection to children.

# Faeco-oral viral hepatitis. Hepatitis A and E.

- Hepatitis A very common. 1.4 million symptomatic cases a year of over 100M.
- Food, water, person-to-person.  Mainly from humans.
- Rare in high-income settings except in high-risk groups.
- There is a highly effective vaccine.
- Hepatitis E less common but more serious, especially in pregnancy.
- From humans and animals.



Hepatitis A.  CDC

# Milk

- Human milk is essential for babies, and provides passive immunity.
- Animal milk and milk products (eg cheese, yoghurt) a central part of the diet for most adults. Mainly cow, but also goat, sheep etc.
- Milk is the principle route of transmission of infections including brucellosis, bovine TB.
- It is a good medium for transmitting many other infections.
- “Improperly handled raw milk is responsible for nearly three times more hospitalizations than any other food-borne disease source” (CDC).

State Library of South Australia.

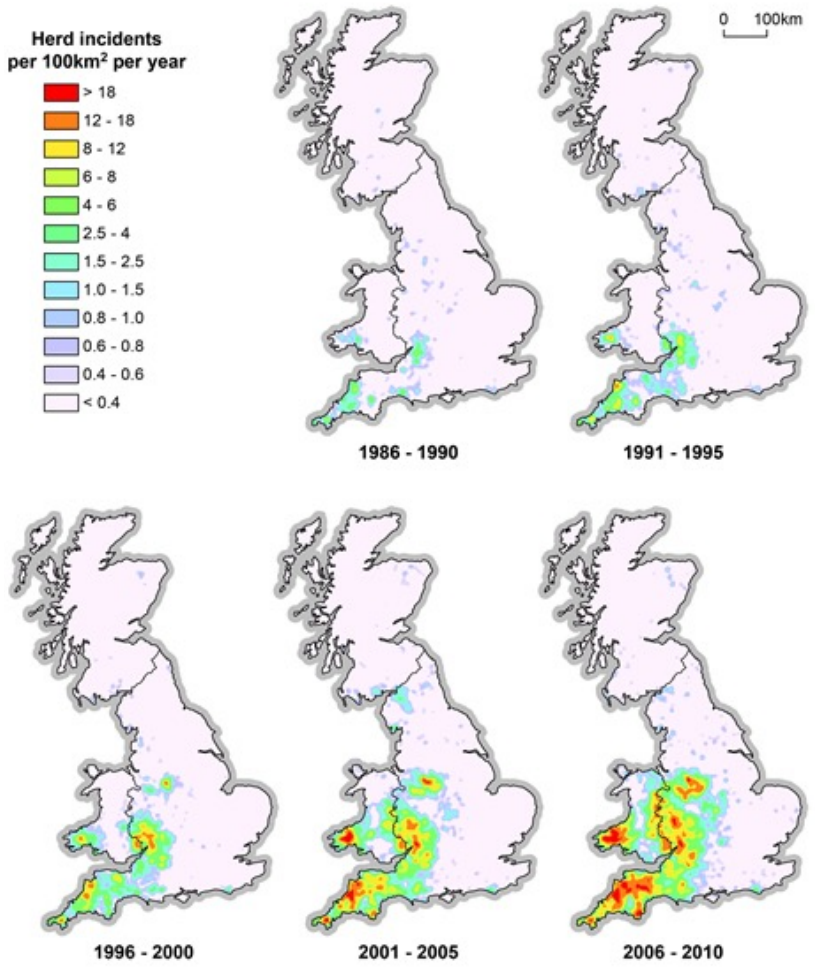
# Brucellosis- almost all from milk and milk products.

- Chronic debilitating fever, can affect bones, joints, reproductive organs.
- Great majority of infections from milk and milk products. Can be occupational, sexual spread.
- Used to be common worldwide. The majority of British cattle herds were affected prior to 1930s.
- Animal husbandry, animal vaccination.
- Now mainly from goats.

Major General Sir David Bruce

# Bovine tuberculosis in humans. Milk.

- Tuberculosis (TB) in cows.
- Excreted in milk.
- When consumed by humans- causes tuberculosis in gut and elsewhere.
- Was very common; around 1600 children a year estimated to die from bovine TB in early 20th C.
- Animal husbandry reduces in herds- but has proved more difficult to eliminate than brucellosis.
- L Bovine TB in cattle UK 1986-2010. (AHVLKA/BBSRC/DEFRA/bovinettb)



# Pasteurisation of milk highly effective at preventing TB, brucellosis and many other infections (and extends shelflife).

- TB, brucellosis, diphtheria, scarlet fever, salmonella, listeria, staphylococcus etc…
- Current pasteurisation heat to 71.7$^{o}$C for at least 15 seconds.
- Compulsory pasteurization of milk to protect children very controversial when brought in between 1920s and 1950s.
- Despite over 65,000 people dying of bovine TB 1912-1937 a strong lobby against, made up of parts of  the dairy industry and those philosophically opposed for several reasons.


Chicago Department of Health 1900

# Unpasteurised milk products.

- Some products are difficult to produce when pasteurised.
- Traditional cheese and yoghurt making kill many bacteria (eg via acidification)- but not all.
- In particular some soft cheeses from unpasteurised milk are a risk to more vulnerable people such as immunosuppressed.
- Pregnant women should avoid them due to *Listeria* (around 10x more at risk) which can cross the placenta.


Drowmale / wiki

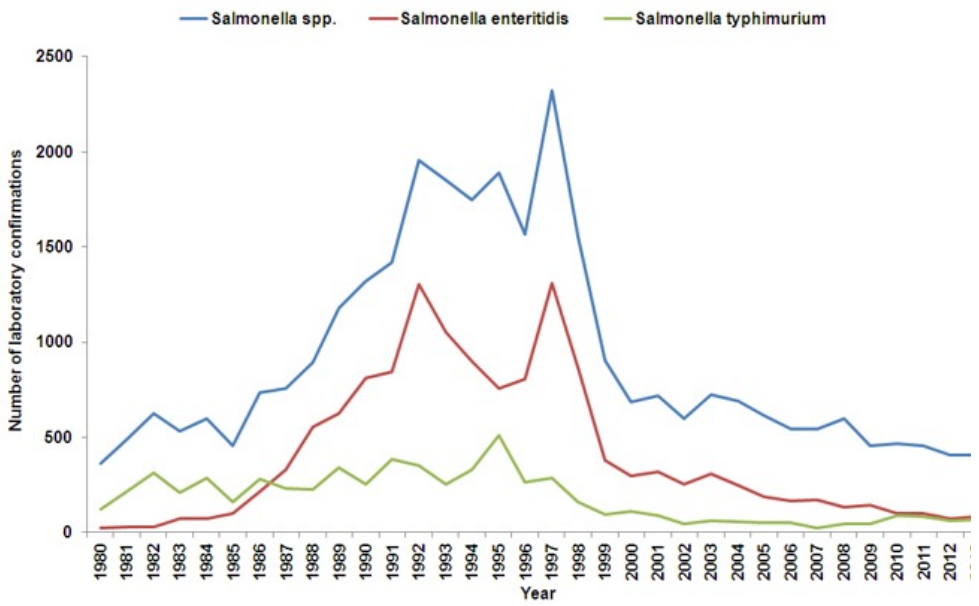
# Breastmilk for babies highly protective against infection.

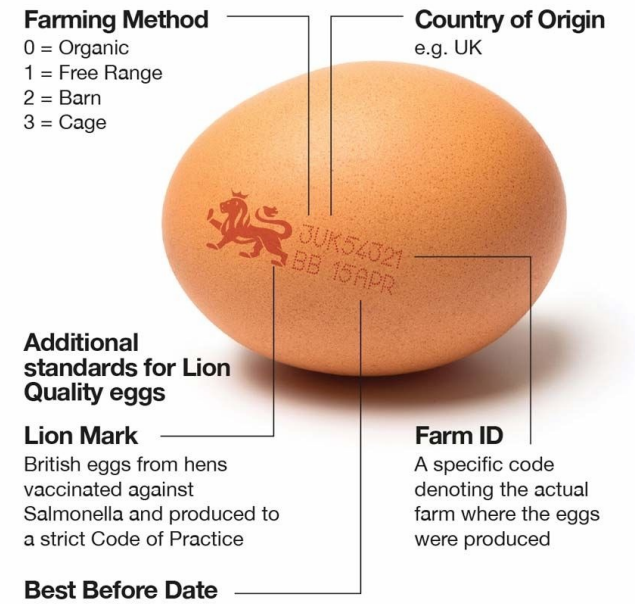
- A safe and ideal form of nutrition for babies.
- Protects against diarrhoeal disease.
- Antibodies from mother to baby (passive immunity) protects against diseases mum is immune to.
- Exclusive breastfeeding for babies in first 6 months recommended by WHO and NHS.
- Small risks of infections- HIV in those with uncontrolled disease.

Louis-Roland Trinquesse 1777

# Eggs and Salmonella.

- Eggs highly nutritious- but from infected flocks can have Salmonella from hens.
- Risk mitigated by cooking until hard.
- Crisis for UK poultry industry mid 1990s due to widespread flock infection. Initially mass slaughter of hens.
- Laboratory-confirmed cases dropped from >18,000 in 1993 to 459 in 2010.
- Poultry vaccination contributed to UK poultry industry recovery.
- Lion Mark eggs highly controlled.
- Risk now very low in UK (but not worldwide).




*PHE/British Lion Eggs*

# Animals and poultry have gut bacteria which can infect humans.

- Animal faeces may get on to meat or poultry in the slaughtering and processing of meat.
- May also contaminate vegetables on farms or preparation.
- Salmonella, campylobacter the most common. ‘Food poisoning’.

Adományozó/Donor: Erdei Katalin. wiki.

# Easy to cross-contaminate when cooking.

- Fully cooked meat, even if contaminated, very low risk.
- Preparing uncooked food with the same utensils or chopping boards as uncooked meat much higher risk.
- Summer barbeques a classic way to achieve cross contamination between cooked and uncooked food.

Hedwig Storch / wiki

# Refrigeration and freezing- another major engineering contribution.

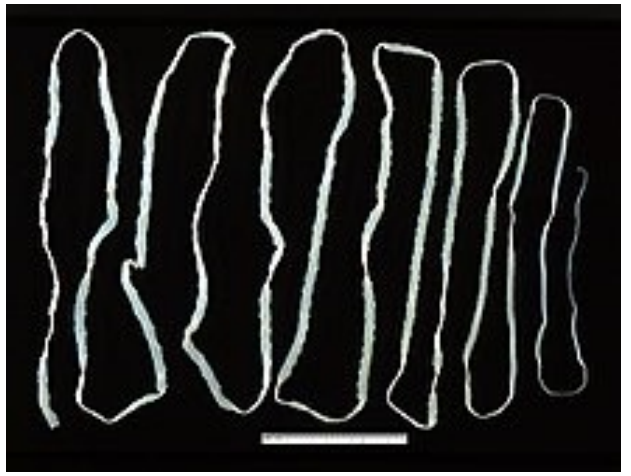
- Refrigeration massively expanded the options for fresh food- keeps longer.
- Also substantially slows expansion of bacterial contamination of food.
- Important pre-cooking.
- Important after cooking.

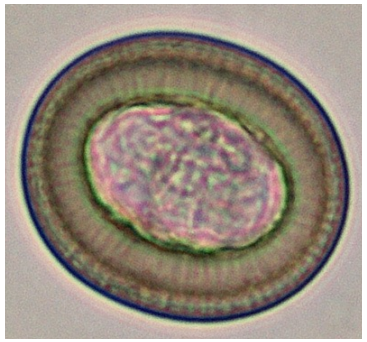
- Freezing. Keeps food longer, and kills some parasites.

GE home refrigerator 1927. Magi Media.

# Beef tapeworm.

- Beef tapeworm in humans can grow up to 20m and live up to 25 years. Sheds eggs.
- Human faeces in fields eaten by cow.
- Cysts form in cow muscle.
- Uncooked measly meat eaten by humans.
- Beef tapeworm largely harmless (but distressing).
- Control: dispose of human faeces, inspect meat, cook beef or freeze it.

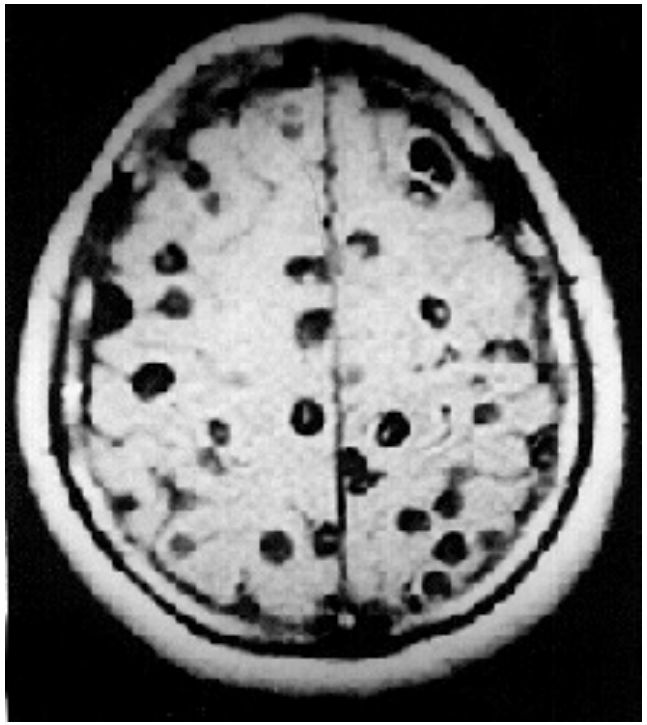




CDFA.gov.ca/S.Walkowski/CDC

# Pork tapeworm and neurocysticercosis.

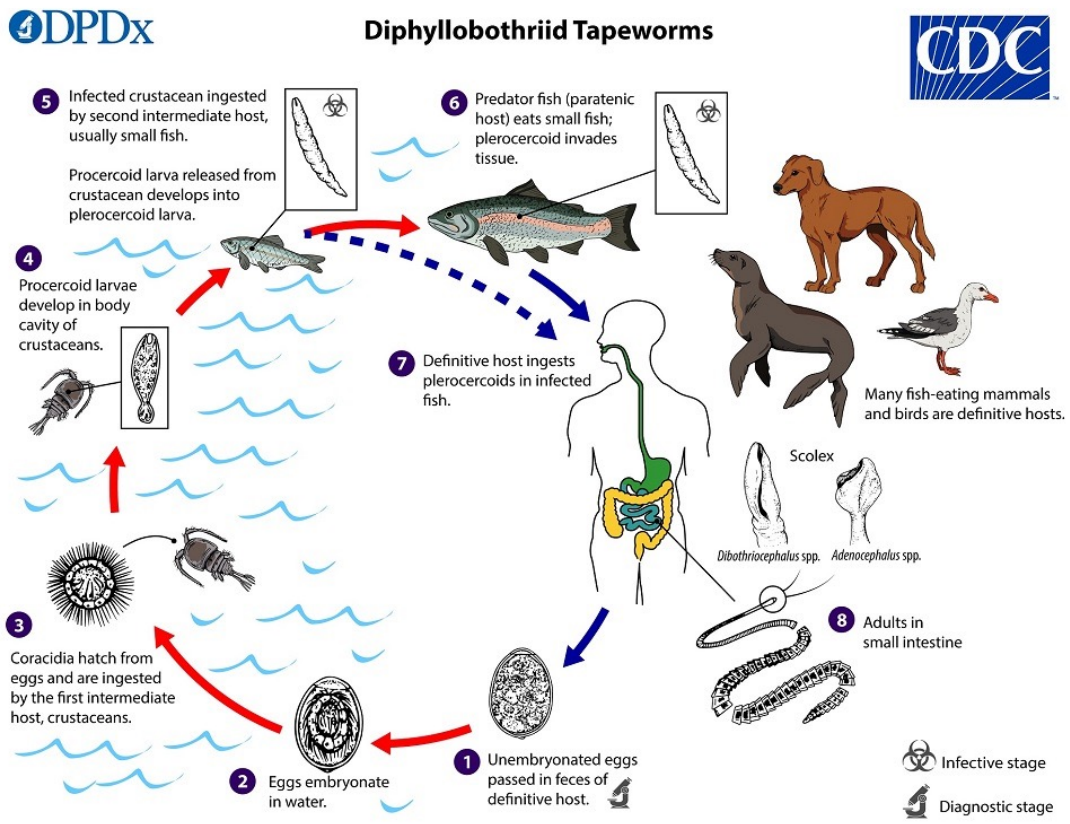
- Lifecycle similar to beef tapeworm: human with tapeworm excretes eggs; faeces eaten by pig; cysts in muscle; undercooked meat.
- Pigs can live close to humans, eat human faeces (and ‘pig toilets’ were common).
- The eggs from human faeces can also infect humans.
- Cysts in muscle, brain of humans.
- A common cause of epilepsy worldwide- in endemic countries 30% (WHO).



CDC

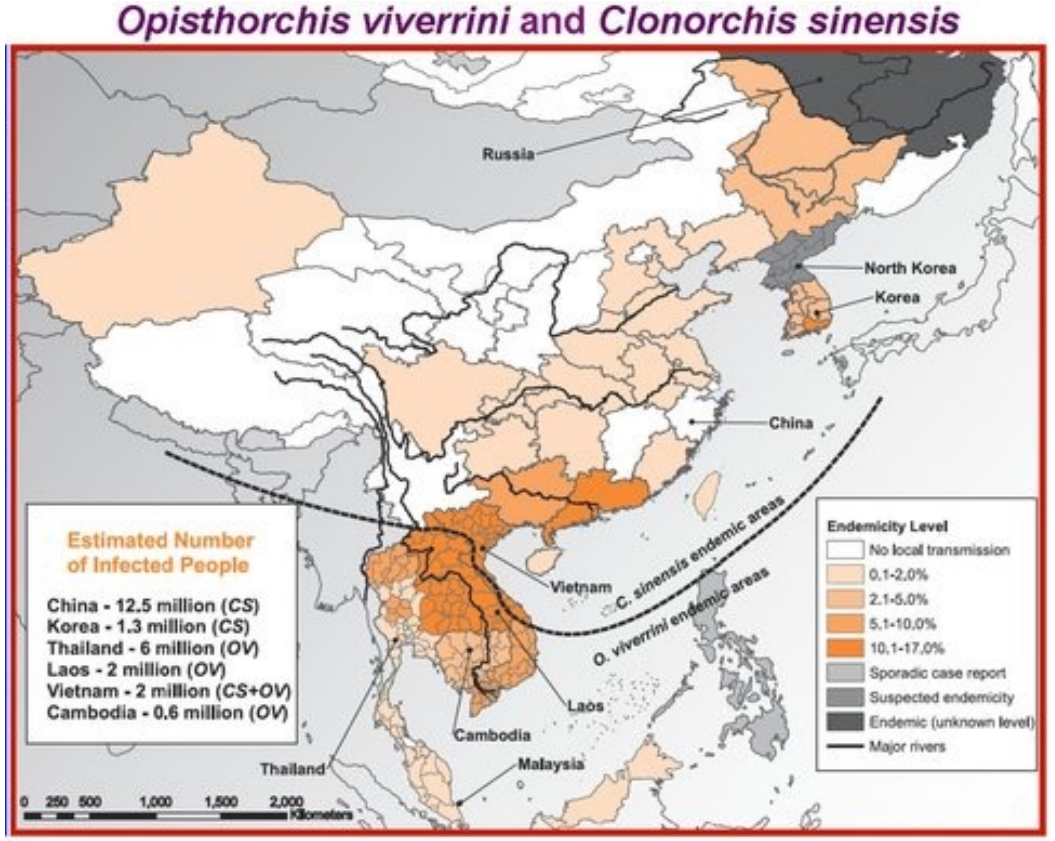
# Diphyllobothriasis- fish tapeworm (very large- up to 10m).

- Humans, bears, dolphins and other carnivores of raw fish definitive host.
- Faeces infects crustacea (first intermediate host), eaten by small fish, muscle cysts. Which are eaten by larger predator fish.
- Large fish infect humans if eaten raw or lightly pickled.
- Freezing or cooking kill the cysts.



# Human liver fluke.

- Asian liver flukes *C. sinensis* and *O. viverrini.* Over 15 million people estimated to be infected.
- Live in bile ducts of liver. Can cause liver and bile duct cancer.
- Eggs excreted and eaten by freshwater snails.
- Parasites swim from snails and infect fish.
- Humans catch by eating uncooked freshwater fish.
- Disposal of faeces, cooking fish.




International Agency for Research on Cancer (IARC), 2012

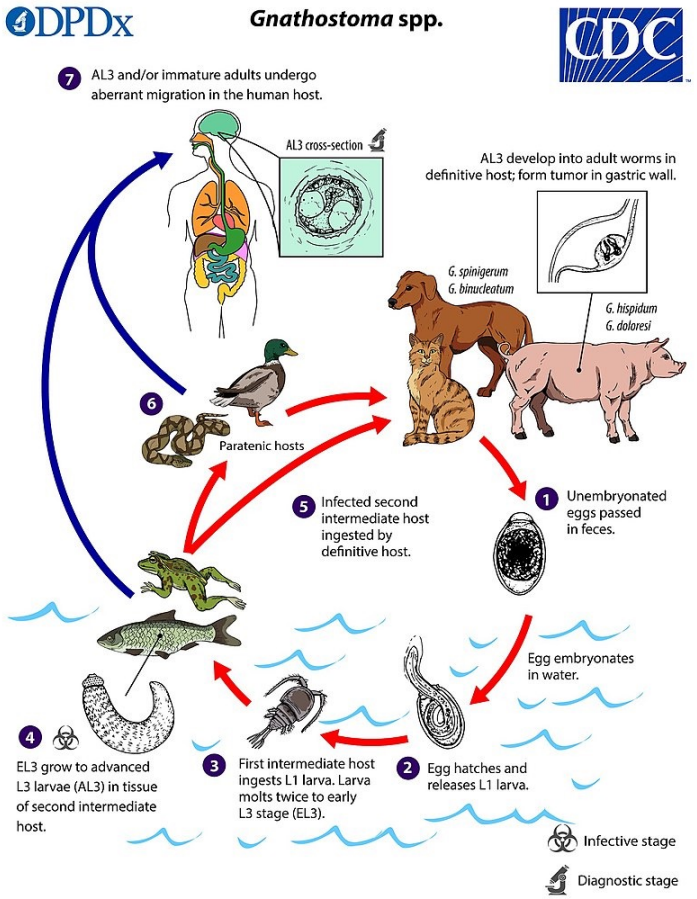
# Humans an ‘accidental’ host.
# Hydatid, a dog-sheep cycle.

- For several parasitic infections humans a dead-end host- but can be severe diseases.
- Hydatid a dog tapeworm,  eggs in faeces infect sheep.
- Sheep develop large cysts (which may kill them). Dogs eat dead sheep.
- Humans infected by dog faeces. Cysts in liver, lung, bones- often difficult to treat.
- Deworm dogs, stop them eating sheep.

*Dr. Mohammad Taghi Niknejad, Radiopaedia*.

# Gnathostomiasis

- The normal cycle has pigs, dogs and other mammals as host of worm.
- Faeces infects fish, frogs and others.
- Humans catch it by eating uncooked fish (typically eels), frogs, snakes.
- Worm larvae can cause bad pain, and invade eye or brain.
- Does not complete lifecycle.
- Uncooked dishes the main risk. Marination or freezing can kill larvae.



# If you eat a meat you don’t know, don’t eat it undercooked…

Some examples where you can get significant parasites:

- Dancing shrimps
- Drunken crabs
- Snake
- Wild boar
- Bear meat
- Giant land snails
- Giant eels


Wiki, Vietnamtravelblog

# Prions.

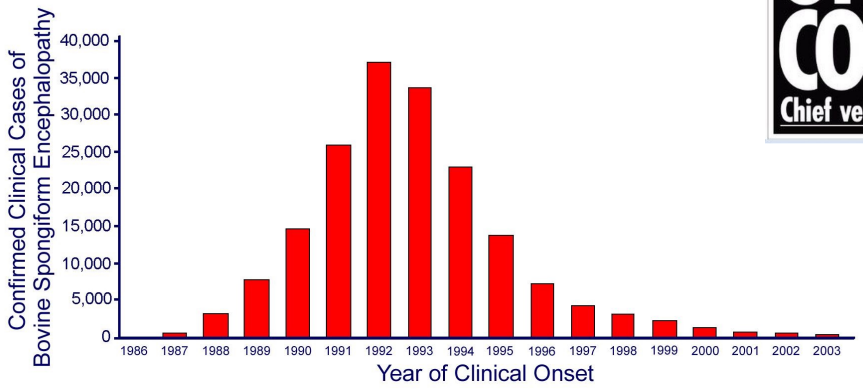
- A misfolded protein- not an infectious disease in the conventional sense.
- Causes neurological diseases.
- Transmitted orally. Several animal diseases such as scrapie in sheep.
- Difficult to denature (sterilise) by conventional cooking or disinfection.
- First discovered in humans as kuru transmitted in funeral cannibalistic rituals.

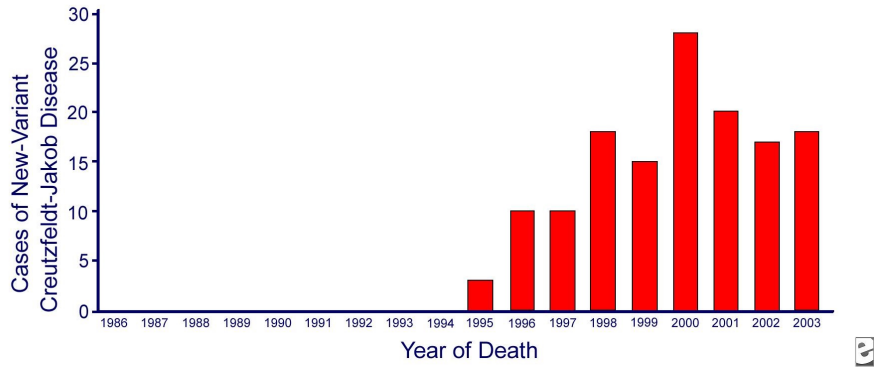
Liberski PP/ wiki

# BSE/vCJD.

- BSE epidemic spread in UK cattle, probably due to feeding them animal remains.
- Subsequently a (mercifully small) epidemic of vCJD in humans.
- Once neurological symptoms start almost universally fatal.
- Key to control



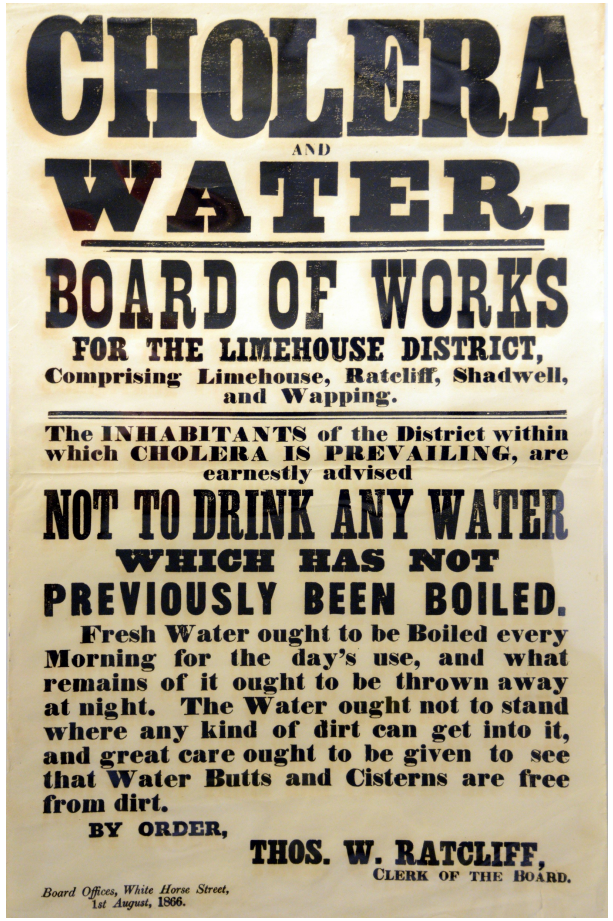



E Krause 2016

# Engineering out many orally transmitted infectious disease epidemics. They used to be massive.

- The provision of sewerage and ample clean water has transformed most of the major oral epidemic infectious diseases.
- Whilst individual infections remain common, and outbreaks occur, they make widespread propagating transmission unlikely.
- The exceptions are areas in poverty, and after disasters.
- The State, and large businesses.



CHOLERA
AND
WATER.

BOARD OF WORKS
FOR THE LIMEHOUSE DISTRICT,
Comprising Limehouse, Ratcliff, Shadwell, and Wapping.

The INHABITANTS of the District within which CHOLERA IS PREVAILING, are earnestly advised

NOT TO DRINK ANY WATER
WHICH HAS NOT
PREVIOUSLY BEEN BOILED.

Fresh Water ought to be Boiled every Morning for the day's use, and what remains of it ought to be thrown away at night. The Water ought not to stand where any kind of dirt can get into it, and great care ought to be given to see that Water Butts and Cisterns are free from dirt.

BY ORDER,
THOS. W. RATCLIFF,
CLERK OF THE BOARD.

*Board Offices, White Horse Street, 1st August*, 1866.

LSHTM

# Farming and food handling.

- Good animal husbandry reduces the chance of infections which can spread to humans.
- Professional abattoirs, clean and refrigerated foodchain and shops.
- Initial washing of vegetables and fruit, keeping free of faeces.
- Mainly the responsibility of multiple small, and some large, businesses.
- The State has a role in inspection, regulation.

Food Standards Agency

# Preparation and serving of food.

- Keeping food refrigerated until use.
- Handwashing after toilet, before food handling, after raw food handling.
- Washing uncooked food.
- Cooking thoroughly.
- Keeping refrigerated afterwards.
- Out of home- small companies,  chains.
- State regulation, some inspection, outbreak investigation.
- Most in the home.

P-A Renoir 1881

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