### Lecture outline

### Framework

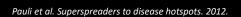
 Individual, species specific, environmental factors influencing transmission

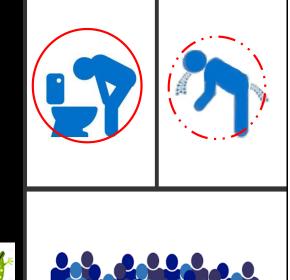
# Three cases to consider

- Typhoid
- Cholera
- Clostridium difficile

# Individual transmission variability

- Contact rates with non-immune hosts
  - Disease associated behaviors
  - Social behaviors across species
- Shedding and infectious potential in injected host
  - Age, sex, body and immune system condition
  - Genetic differences in host resistance
- Infectious particle virulence
  - Duration and intensity of infectiousness
  - Ease of transmission
- Genotype-environmental interactions







# Species-level transmission variability Species host susceptibility and contact rates with vectors or other hosts Host competence (efficiency with which a host produces and transmits a pathogen) -Ex: Pig is very infectious. Porcupine is infected, but not infectious. Amplification hosts and "superspreading species" -Ex: Species that can rapidly replicate and often interact with very susceptible species


# Environmental transmission variability

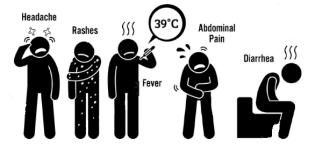
- High pathogen prevalence
- High intensity
  - Many pathogens per infected host
- High transmission rates due to environmental conditions allowing for
  - Elevated pathogen survival
  - Greater density of amplification hosts

Pauli et al. Superspreaders to disease hotspots. 2012.

# Typhoid fever

Salmonella typhi

- Aerobic gram negative rod
  - · Fecal oral transmission
  - Minimum effective dose ~100 cells
  - Hygiene and proper disposal of feces
  - 15% mortality
- Clinical disease: Fever, headache, abdominal pain, "rose-colored" spots
  - Incubation period 5-21 days
  - Diarrhea symptoms may pause and then recur
- Carrier state: 2-5% affected are asymptomatic, chronically shed organisms with inconsistent eradication of shedding even with antibiotic



Gunn et al. Salmonella chronic carriage. 2014.

### **Amplification species** • Flies breed in human feces, unaffected by bacteria Individual • Feet carry enough bacteria to Environmental spread disease to food left • Carrier state is • Poor sanitation allows open to air asymptomatic and contamination of water • Synanthropic flies attracted to common in older women supply foul breath and open mouths of • Poor hygiene in food • Large groups of nonsick and under nourished preparer major source of immune hosts combine humans transmission with asymptomatic carriers Symptoms resolve and • Heat and humidity makes recur feces more fragrant → Flies • Low bacterial load needed with larger breeding for effective transmission grounds Historical outbreaks of epic proportions in military camps Typhoid Mary Citations 3-5

# Cholera-Vibrio cholerae

- Aerobic, gram negative curved rod invades small bowel
  - Spread by ingestion of contaminated food or water
    - 1 ml stool → ~hundred million viable vibrio
  - Several million bacteria must be ingested
    - Dose reduced in persons with reduce gastric acid
    - Children ages 2-4 and Type O blood more susceptible to infection
  - Most infections mild-moderate
- Clinical disease: Abrupt onset painless, high volume watery diarrhea >250ml/kg in first 24 hours
  - Incubation period 18h-40 hours
  - Vomiting, muscle cramps with severe dehydration to shock, renal failure and metabolic acidosis
- Carrier states x 2
  - Convalescent carriers- shed for weeks-months after symptoms gone
  - · Chronic carriers- shed asymptomatically for years



### Individual

- Asymptomatic and convalescent carrier states
  - May be rapidly fatal, but most infections mildmoderate
- High inoculum needed for infection easily present in massive efflux of stool in new infections
- Antibiotics decrease vibrio concentration in stool

### **Species**

- Shellfish and plankton (blooms) can be infected and then ingested improperly cooked.
- Water hyacinth plants may help sustain vibrio/mosquito populations.
- Toxic and non-toxigenic strains bacteriophages transfer toxicity genes for human infection and vibrio motile

### Environmental

- Upstream sanitation breakdown spreads through pre-existing water channels
- Large groups of non-immune hosts may share a limited resources for rehydration
- Vibrio in high concentrations in fresh and brackish water.
- Rain may worsen risk of infection with overflow of brown/black waste water.

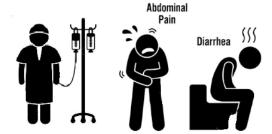
Outbreaks rapidly outstrip available resources +

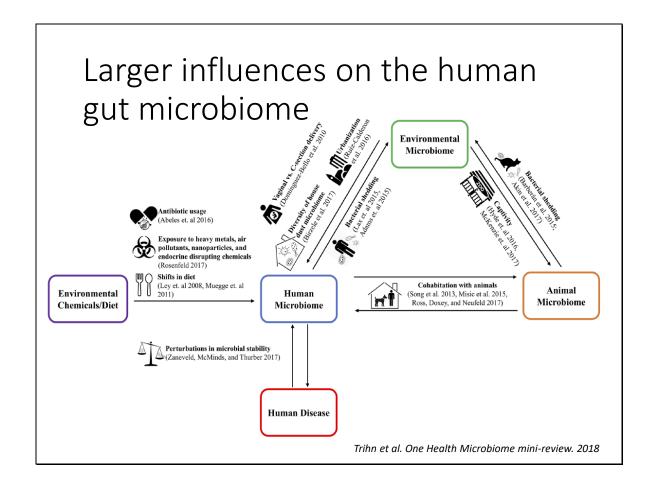
Haiti

Citations 6-8


## C. diff-Clostridium difficile

- Anaerobic gram positive spore forming rod
  - ~20% of antibiotic associated diarrhea
  - · Toxin production causes colitis
- Clinical disease: Acute or chronic diarrhea, stomach cramps, and occasional fever.
- Adult gut has colonization resistance
  - Gut microbiota depletion post-antibiotic allows C. diff to overgrow
  - Antibiotic exposure remains major risk for clinical disease
  - PO vancomycin or fecal transplant for treatment
- Normal commensal in infants
   – carrier state identification is laborious
  - 3% of non-hospitalized adults estimated to be colonized vs 20-40% of hospitalized adults.





### **Species** • Antibiotic exposure ubiquitous Individual -depletes normal human gut microbiome • Normal commensal with • Bi-directional spread of C. diff adult gut with Environmental between human and farm colonization/overgrowth animals (cows, pigs, vegetables, • Spores remain dormant until resistance with compost material) and service human gut microbiome questionable "infective animals/pets. suitable for growth dose" • Spores difficult to kill with • Affected individuals heat or antiseptic/antibiotic sporadic • Concentrated vulnerable • "Hypervirulent strain" persons in hospitals get may be responsible for antibiotics over extended increased mortality. periods of time Rising incidence in developed world Antibiotic stewardship/Fecal transplant Citations 9-10


# **Brief citations**

- 1) Pauli et al. "From super spreaders to disease hotspots: linking transmission across hosts and space." Front Ecol Environ. 2012 10(2): 75-82.
- 2) Gunn et al. "Salmonella Chronic carriage: epidemiology, diagnosis and gallbladder persistence." Trends Microbiol. 2014 22(11): 648-655.
- Gradmann, Harrison and Rasmussen. "Typhoid and the military in the early 20<sup>th</sup> century." CID. 2019 69 (S5): S385-S387.
- 4) Cirillo. "Winged Sponges' houseflies as carriers of typhoid fever in 19<sup>th</sup> and early 20<sup>th</sup> century military camps." Perspectives in Biology and Medicine. 2006 Winter: 52-63.
- 5) Kim et al. "Spatial and temporal patterns of typhoid and paratyphoid fever outbreaks: A worldwide review 1990-2018." CID. 2019 69(S6): S499-S509.
- 6) "Cholera: Something old, Something new." Sigman and Luchette. Surgical infections. 2012 13(4): 216-222.
- 7) Lantagne et al. "The cholera outbreak in Haiti: Where and how did it begin?" Cur. Top. in microbiology and immunology. 2013.
- 8) Feikin et al. "Short report: Does water hyacinth on East African Lakes promote cholera outbreaks?" Am. J. Trop. Med Hyg. 2010. 83(2): 370-373.
- 9) Trinh et al. One health relationships between human, animal and environmental microbiomes: A mini-Review." Frontiers in Public health. 2018 6(235).
- Lim et al. "Clostridium difficile and One health." Clinical microbiology and infection. 2019. CMI 1820.