Microbes are Different

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Habitats of Human and Animal Pathogens

- Human adapted pathogens
  - Obligate host specificity
- Animal pathogens infecting humans
  - Zoonotic pathogens, animal reservoir
- Opportunistic pathogens
  - Normal flora of humans
  - Environmental organisms
    - Natural inhabitants of the environment
    - Animal or human environmental contaminants

Diagnosis of Infectious Diseases

- Clinical diagnosis
  - Physician knowledge and experience, empirical
- Laboratory diagnosis
  - Laboratory tests, objective
- Other diagnostic procedures
  - Medical instruments, e.g. CT scan, MRI, etc.

Epidemiological Surveillance

- Passive case reporting
- Active case acquisition
- Surveys
- Projects (research initiatives, etc.)

Outbreak Investigations

- Reactive
  - ✓ Represents failure of preventive measures
- Retrospective
  - ✓ Occur after the event, people already sick

Limitations of Our Knowledge About Pathogens

- Historical
  - ✓ Based upon knowledge and experience, difficult to anticipate or recognize emerging pathogens
- Interactive
  - ✓ Depends upon interactive cooperation between patient, physician, laboratorian, and epidemiologist
- Methods dependent
  - ✓ Pathogen specific media and reagents required

Microbes in the Environment

- Ecological research
- Environmental monitoring
  - Discharges, e.g. sewage, industrial, agricultural
- Animal impact on the environment
  - Feral animals
  - Agricultural discharges
    - CAFOs
    - Land application of manure

Microbes in the Environment

- Quality of source and drinking water
  - ✓ Source water protection
  - ✓ Drinking water treatment efficacy
    - Fecal indicators as pathogen surrogates to measure disinfection efficacy and the integrity of distribution systems
    - Heterotrophic plate counts to measure disinfection efficacy and detect presence of biofilm
  - ✓ Pathogen monitoring
    - Rarely performed, methods limitations, high cost

NRC Health Effects Attributes

- **Severity** is defined as the clinical magnitude of illness at the most sensitive health end point
  - ✓ Who is infected?
    - Populations at risk
  - ✓ What is the outcome?
    - Health impact for the patient or populations
  - ✓ How is it measured?
    - Limitations of available data

NRC Health Effects Attributes

- **Potency** is the power or strength of a pathogen to produce disease.
  - ✓ Infective dose variable by route of exposure
  - ✓ Infective dose variable by strain of pathogen
  - ✓ Host response variable by health and immune status
  - ✓ Measurable for only a few pathogens for a few populations

NRC Environmental Occurrence Attributes

- **Prevalence** is the frequency and concentration (density) of pathogens in drinking water
  - ✓ Must be able to detect pathogen in distribution water using available methods
  - ✓ Must know temporal, spatial and longitudinal distribution of pathogen present as non-uniform aggregates in distribution water
    - Point source contamination
    - biofilms
  - ✓ Limited data available for few pathogens

NRC Environmental Occurrence Attributes

- **Persistence** is the likelihood that a pathogen will be found in the aquatic environment, based upon its biological properties
  - ✓ Presence in distribution system water
    - Total counts (viable and non-viable)
    - Total (viable) plate count variability
  - ✓ Survival in distribution water
    - Culturable vs. viable but non-culturable organisms
  - ✓ Infectivity of pathogens under ambient conditions
  - ✓ Data available for few know pathogens

NRC Environmental Occurrence Attributes

- **Mobility** is the ability of pathogens to move or be transported through the environment and in distribution systems
  - ✓ Microbial particle dynamics vs. chemical solute properties
  - ✓ Aggregates (micro-colonies) vs. individual cells
  - ✓ Biofilm behaviors and mechanics
  - ✓ Biological factors, e.g. amoeba sequestering and transport
  - ✓ Data available for few known pathogens

NRC Health and Environmental Occurrence Attributes

- **Magnitude** is the amount of a pathogen in drinking water delivered to the tap relative to the infective dose
  - ✓ Microbial growth or decline in the environment (population dynamics of microorganisms)
  - ✓ Methodological limitations (sampling, culture, etc.)
  - ✓ Temporal spatial, and behavioral variability of pathogens
  - ✓ Host response variability
  - ✓ Data available for very few if any known pathogens

VFARs as Alternatives

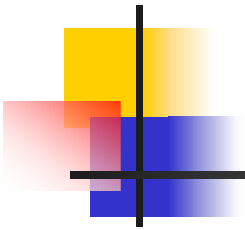
- Sequencing of bacteria genomes is progressing rapidly
- Sequenced genomes show remarkable ability to add or loose genes
- Virulence is frequently mediated by non-chromosomal genetic material, e.g. plasmids or bacteriophage
- New pathogens may arise by addition of virulence genes or plasmids

Family Trees

- Based on similarity
- Organisms members of related groups
- Strains, species, genera
- Genes are related to each other, gene families

Family membership = information

- 24 million of 44 million and expanding rapidly
- Family: toxin genes go on to PCCL
- Family: recombination genes exclude



The State of Knowledge Paradox

The more we learn, we realize the less we know.

There are no easy answers.

Limitations of Indicator Monitoring

- Measures only pathogens shed in feces of humans and animals
- Correlates poorly with presence of parasites and viruses in water
- Limited to measuring the efficacy of water treatment and the integrity of the distribution system
- Does not detect presence of opportunistic pathogens

Limitations of Knowledge About Pathogens in the Environment

- Uncertainty is measured by orders of magnitude in microbiology
- Variability is manifested by wide differences in infectivity of pathogen strains and host susceptibilities
- Conventional method cannot predict emergence of new pathogens
- Methodology limitations impede progress