Transmission Mechanism of Environmental Pathogens

By

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Significance of the Pathogens in the Environment

- Public Health
  - ~ 75 million cases of water and food borne diseases reported annually (Jenkins and Bowman, 2004)
  - Globally, over 2 million persons die each year from drinking unsafe water (Kosek et. al., 2003)
Many community-acquired pathogens have developed resistance to antibiotics (Goosens and Sprenger, 1998)

- Pathogens are the second leading cause of natural water impairment (5300 of 22,000 waters) (USEPA, 2000)
What drives the emergence of pathogens?

1. Change in land use or agricultural practice
2. Change in human demographics and society
3. Poor population health (e.g. HIV, malnutrition)
4. Hospitals and medical procedures (e.g. MRSA)
5. Pathogen evolution (e.g. MAR)
6. Contamination of food sources or water supplies
7. International travel
8. Failure of public health programs
9. International trade
10. Climate change

From: Woolhouse and Gowtage-Sequeria, 2005
Where do the pathogens originate?
Fecal material of warm-blooded animals/humans

Studies show that the 12,000 dogs living in a suburban Washington D.C. watershed leave behind more than 5,000 pounds of "solid waste" every day
- An estimated 238,000 working farms and ranches in the United States generate about 500 million tons of manure each year

Unusual sources
- Water runoff collected directly from the parking lots can contain between 9,000 and 100,000 E. coli per 100 ml Meier et al., 2000
What are the sources of pathogens?

- Agricultural Runoff and Infiltration
- Domestic animals
- Urban Runoff
- Septic Systems
- Sewage Lines
- Straight Pipes
- Wildlife
- Biosolids
What is infection and its type?

1. **Infection**: growth and multiplication of a microbe in or on the body with or without the production of disease.

2. **“Pathogenicity.”** The ability of organism to cause disease is called pathogenicity.

3. **Virulence** is the measure of the pathogenicity of a microorganism.

4. **Pathogenesis** refers both to (1) the mechanism of infection and to (2) the mechanism by which disease develops.
Routes of transmission

- **Direct**
  - Skin-skin
    - Herpes type 1
  - Mucous
  - Across placenta
    - toxoplasmosis
  - Through breast milk
    - HIV
  - Sneeze-cough
    - Influenza

- **Indirect**
  - Food-borne
    - Salmonella
  - Water-borne
    - Hepatitis A
  - Vector-borne
    - Malaria
  - Air-borne
    - Chickenpox

**Exposure**
A relevant contact – depends on the agent
Skin, sexual intercourse, water contact, etc
COVER UP!

Your coughs and sneezes

Actual photograph of a sneeze

SPRAY SPREADS

Colds • Flu • Tuberculosis
Disease is the result of forces within a dynamic system consisting of:

agent of infection
host
environment
Factors Influencing Disease Transmission

**Agent**
- Infectivity
- Pathogenicity
- Virulence
- Immunogenicity
- Antigenic stability
- Survival

**Environment**
- Weather
- Housing
- Geography
- Occupational setting
- Air quality
- Food

**Host**
- Age Sex
- Genotype
- Behaviour
- Nutritional status
- Health status
Susceptible Host

- Susceptibility varies with each individual and is dependent on:
  - Infectious dose (Shigella vs. Salmonella)
  - Internal resistance
    - WBC migration response
  - Age
  - Underlying disease (diabetes, cancer, HIV/AIDS)
Chain of Infection

Etiologic Agent \(\rightarrow\) Transmission \(\rightarrow\) Host

Pathogenicity
Infection dose
Reservoir
Source

Contact
Common vehicle
Airborne
Vector

Individual host factors
Nonspecific-resistance
Specific-immunity
Reservoirs of infectious disease
Reservoir of pathogen affects extent and distribution of disease
Recognizing reservoir can help protect population from disease
Reservoirs can be
Human
Non-human animal
Environmental
• Human reservoirs
  Infected humans most significant reservoirs
  Primarily of communicable diseases
  In some cases humans are only reservoir
  In this case disease is easier to control

Human reservoirs as
Symptomatic infections  Obvious source of infectious agents
  Ideally infected individuals understand the importance
  of precautions such as hand washing to inhibit transmission
Asymptomatic carriers
Individual harbors pathogen with no ill effects
They may shed organisms intermittently for long periods of time
Some have asymptomatic infection
More likely to move about spreading pathogen
Non-human animal reservoirs

*Source of some pathogens*
Disease transmitted by non-human animal reservoirs are termed *zoonotic*
Disease often more severe in humans than in normal animal
Infection in humans is accidental

Environmental reservoirs
Some pathogens have environmental reservoirs which can include
Water
Soil
These pathogens difficult or nearly impossible to eliminate
Chain of Infection

Infectious agent
- Bacteria
- Viruses
- Fungi
- Protozoa
- Helminths

Susceptible host
- Neonates
- Diabetics
- Immunosuppressed
- Cardiopulmonary disease

Reservoir
- People
- Equipment
- Water

Portal of entry
- Broken skin
- Mucous membrane
- Gastrointestinal/respiratory/urinary tract

Portals of exit
- Excretions
- Secretions
- Droplets
- Skin

Means of transmission
- Direct contact/fomite
- Injection/ingestion
- Airborne/aerosols
Infectious Agents

- Bacteria
- Viruses
- Fungi
- Protoctists / Protozoa
- Helminths
Reservoirs

- A host that carries a pathogen without injury to itself and serves as a source of infection for other host organisms (asymptomatic infective carriers)
- Humans
  - {hepatitis}
- Other Vertebrates
  - {zoonoses}
- Birds & Bats
  - {histoplasmosis}
Vectors

- A host that carries a pathogen without injury to itself and spreads the pathogen to susceptible organisms (asymptomatic carriers of pathogens)
Other parasites have life cycles that involve intermediate organisms, or *vectors*, which carry disease-causing microorganisms from one host to another. The protozoan blood parasite that causes sleeping sickness, or *trypanosomiasis*, infects humans, cattle, and other animals. It uses the *tsetse fly* as a vector to carry it from one host to the next. When a tsetse fly bites an infected animal, it picks up the parasite when it sucks blood. When an infected fly bites another animal, the parasite enters the bloodstream and begins to reproduce in the new host.
Arthropod Vectors

- **Pathogen – Vector**
  - Viruses (Arbovirus) – Mosquitoes
  - Bacteria (Yersinia) – Fleas
  - Bacteria (Borrelia) – Ticks
  - Rickettsias (R. prowazeki) – Lice, ticks
  - Protozoa (Plasmodium) – Mosquitoes
  - Protozoa (Trypanozoma) – Tsetse flies
  - Helminths (Onchocerca) – Simulium flies
Ecological Factors in Infections

- Altered environment {Air conditioning}
- Changes in food production & handling
  - {intensive husbandry with antibiotic protection; deep-freeze; fast food industry}
- Climate changes
- {Global warming}
- Deforestation
- Ownership of (exotic) pets
- Air travel & Exotic journeys / Global movements
- Increased use of immunosuppressives/ antibiotics
Sources of Infectious Agents

- Human sources include patients, healthcare workers, household members, visitors, casual contacts, friends, etc. Source can be symptomatic, asymptomatic or in incubation period.

Most common colonized/infected sources include skin, respiratory and gastrointestinal tracts.
Modes of Transmission

- Three primary modes of transmission

1. Contact (direct and indirect)
2. Respiratory droplets ($\geq 5$ microns)
3. Airborne droplet nuclei ($\leq 5$ microns)
Transmission

Successful pathogen must be passed from reservoir to next susceptible host.

Transmission of pathogen via contact with food, water or living agent is termed horizontal transmission.

Transmission via transfer of pathogen from mother to fetus or child through breast feeding is termed vertical.

Contact

- Direct contact
  - Occurs when one person physically touches another.
    - Can range from simple contact to intimate contact.
  - In some cases direct contact is primary route of transmission.
Direct contact

Microorganism transferred directly from one person to another (occurs more often between patients and HCW than between patients except in special patient populations such as long term care, board and care facilities)
Blood from HBV/HCV/HIV infected person injected into or has contact with open skin lesion
Scabies might transferred from infected person to non−infested person
Unprotected (ungloved) contact with infectious agent (oral care on patient with asymptomatic or symptomatic without wearing gloves)
Indirect Contact
Most frequent involves transfer of infectious agent through contaminated intermediate object or person

Hands are cited most frequently

Hands touch infected or colonized body site or contaminated inanimate object then subsequently touch another person without performing hand hygiene
Hands are main vehicle of contact transmission
Handwashing physically removes organisms
Important in preventing direct contact transmission
Pathogens that do not survive for extended periods in the environment usually spread by direct contact
indirect contact
Involves transmission of pathogens via inanimate objects or fomites
Usually clothing, tabletops, doorknobs and drinking glasses
Organisms on hands or fingers of carrier can be transferred to objects and picked up by another individual
Handwashing is an important control measure
Indirect Contact (con’t)
Patient care devices (electronic thermometer, blood pressure cuff, stethoscope, glucometer) contaminated with skin microorganisms, blood and body fluids (HBV/HCV/HIV) and shared between patients without disinfection.
Indirect Contact (con’t)
Shared toys contaminated with virus.

- Instruments inadequately cleaned before disinfection or sterilization between patients (endoscopes, surgical instruments) or have manufacturing defects that prohibit proper cleaning.
Droplet Transmission

A form of contact transmission
Mechanism of transfer to host is distinct
Additional infection control measures needed
Traditional definition
Microorganism droplet size $\geq 5$ microns and could be propelled no more than 3 feet from the infected person in any direction
The distance a droplet can travel depends on number of factors:

- Velocity
- Mechanism by which microorganism is propelled into the air (weak or no cough vs. paroxysmal cough)
- Temperature and humidity
- Density and amount of respiratory secretions
- Droplets are relatively heavy with moisture
- Do not remain suspended in air for long periods of time
- Transmission is generally by contact with mucous membranes of mouth, nose, eyes
Transmission/Exposure Routes of Infectious Agents: Entry to and/or Exit From the Body

Sites or Portals of Exit or Entry:

- Respiratory
- Enteric or Gastrointestinal
- Skin: especially if skin barrier is penetrated
- Genitourinary
- Eye
Airborne Transmission

- Dissemination of droplet nuclei (moisture surrounding nuclei evaporates) leaving small-particle residue ≤ 5 microns that contains infectious microorganisms
- Droplet nuclei remain suspended in air for long periods of time
- Can be carried by air currents or on dust particles
Dispersal also depends on velocity of air currents, temperature and humidity.

In contrast to droplets (settle on mucous membranes or conjunctiva) airborne particles are inhaled by susceptible host.

Exposure can occur in same room or over longer distances from source.
Examples of airborne infectious agents

Varicella zoster – chickenpox
*Mycobacterium tuberculosis*
Severe acute respiratory syndrome (SARS)
Smallpox
Viral Hemorrhagic Fevers (Marburg, Ebola)
Standard Precautions

- Assumes every person/patient potentially infected or colonized with a microorganism that could be transmitted and cause an infectious process
- Hand hygiene program
  Waterless alcohol-based product or soap and water before and after patient contact, removal of gloves, contact with contaminated objects
- Avoid artificial nails, extenders, etc.
Personal Protective Equipment (PPE)

HCW/patient interaction dictates when and what type of PPE to be worn

- Gloves – anticipated contact with blood, body fluids, soiled skin, mucous membranes, non-intact skin
  Remove gloves immediately after terminating contact with patient/contaminated environment contact and perform hand hygiene
  Gloves should be durable and fit properly
Gowns
Long-sleeve gown or apron depends on extent of blood or body fluid exposure
Protects skin and prevents soiling of clothing
Fluid or moisture proof or repelling
Mouth, nose, eye protection
Surgical mask, eye protection (goggles) or face shield when splashing or spraying of blood, body fluids anticipated–Suctioning and wound irrigation or patient’s cough productive, spontaneous
Remove PPE immediately when no longer needed and perform hand hygiene
Droplet transmission

- Microbe-laden respiratory droplets generally fall to the ground within three feet of release
- People in close proximity can inhale infected droplets spreading disease via droplet transmission
- Droplet transmission considered direct transmission because of the close range required for transmission
Food and water

- Pathogens can be transmitted through contaminated food and water
- Food can become contaminated in number of different ways
  - Organisms can originate with animal
  - Organisms can be inadvertently added during food preparation
  - Cross-contamination occurs when organisms from one food is transferred to another from an improperly cleaned work surface
    - Cutting boards and knives
- Sound food handling practices can prevent foodborne transmission and disease
Transmission Routes of Infectious Agents

- **Respiratory or salivary spread**
- **Faecal-oral spread**
- **Venereal spread**

**Zoonoses**
Infections acquired from animals (arthropods, vertebrates).
Human infection controlled by controlling animal infection.

- **Vector (biting arthropod)**
  - Malaria
  - Sandfly fever
  - Typhus (louse-borne)

- **Vertebrate reservoir**
  - Brucellosis; rabies
  - Q fever; lassa fever
  - Salmonellosis

- **Vector-vertebrate reservoir**
  - Plague
  - Trypanosomiasis
  - Yellow fever
Factors Influencing Exposure and Infection: Agent (Microbe) Factors

Sources, Reservoirs, Transport and Persistence (in the Environment)

Ability to Enter a Portal in the Human or Other Host

Ability to Reach and Proliferate at Site(s) of Infection in the Host

Excretion of the Agent from the Host

Quantity and "Quality" (including virulence) of the Infectious
Environmental Factors Influencing Survival or Proliferation of Infectious Agents

- **Physical:** temperature, relative humidity, sunlight, moisture content or water activity, climate and weather, etc.
- **Chemical and Nutritional:** Antimicrobial chemicals, nutrients for microbial proliferation.
- **Biological:** Antagonistic activity by other organisms: antimicrobial agents, parasitism, etc.; presence and state of a vector
Factors Influencing Exposure and Infection: Host Factors and Host Susceptibility

- **Opportunities for host exposure**
  - transmission routes
  - host availability

- **Susceptibility factors**
  - Dosage (quantity) and "quality" of infectious organisms, including their "virulence";
  - age
  - immunity
  - nutritional status
  - immunocompetence and health status,
  - genetics
  - behavior (personal habits) of host.
Destruction/Removal of Harmful Microorganisms
Hands Spread Disease

WASH 'EM !!!
Thank you