7th lecture:

EPIDEMIOLOGY OF INFECTIOUS DISEASES

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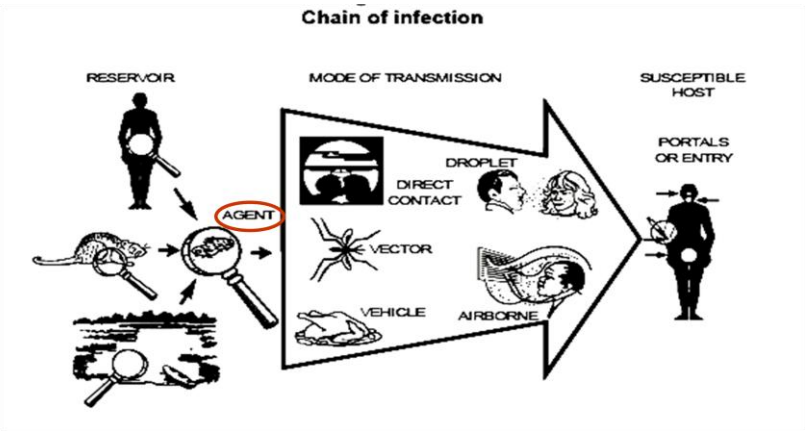
LECTURE OBJECTIVES:

By the end of this lecture student will be able to:

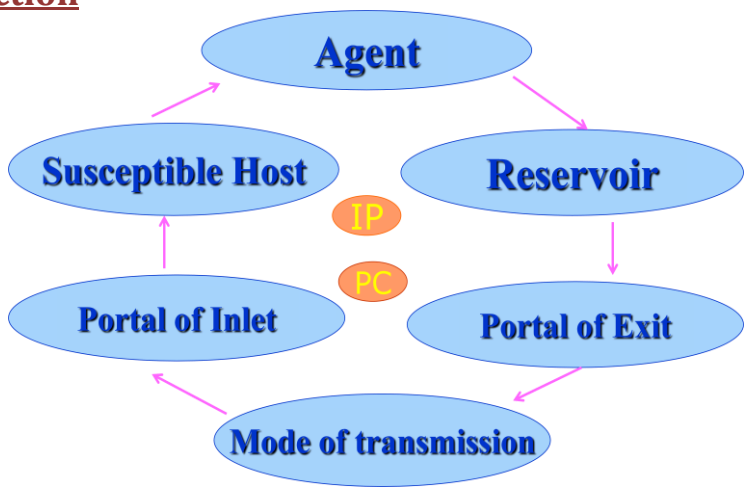
- Describe the infectious disease process (Chain of infection)
- List the types of reservoir of infectious diseases of man
- Define a carrier and list its types.
- Define zoonoses and list examples.
- Identify the different modes of transmission of the organisms from the reservoir to the susceptible host.

Chain of infection



A process that begins when an *agent* leaves its *reservoir* or host through a portal of *exit*, and is conveyed by some *mode of transmission*, then enters through an appropriate portal of *entry* to infect a susceptible *host.*

Cycle of infection



The requisites (essentials) for the perpetuation of communicable diseases:

The elements of the cycle of infection:

1. Presence of microbiological agent.
2. Presence of reservoir.
3. Portal of exit.
4. Mode of transmission.
5. Portal of entry (inlet).
6. Presence of susceptible host.

1. *Agent:*

- ✓ Microorganisms are responsible for disease production (viruses, bacteria, protozoa, parasites, fungi...
- ✓ Agent factors that affect disease transmission: *Infectivity, Pathogenicity, Virulence, Antigenicity*…

❖ Infectivity

It is the ability of an agent to invade and multiply (produce infection) in a susceptible host.

The first case of an infectious disease which starts the chain at a specific area at a specific time is called the primary case. All other cases after it that are due to this first case or its chain are called the **secondary cases.**

Example 1: the first child to have measles in a class is the primary case but all the other children that get infected due to that first student are called secondary cases. Some kids in that class can be vaccinated thus they are not considered susceptible hosts.

To measure infectivity we check how many susceptible hosts are found in the population we are studying, and then we check the number of secondary cases; the ratio/percentage of those susceptible persons that get infected is the infectivity of the microorganism.

How to measure (**Infectivity);** ease & spread of infection?

Secondary Attack Rate

It is the proportion of exposed susceptible persons who become infected.

$$Secondary\ attack\ rate = \frac{Number\ of\ secondary\ cases}{Number\ of\ susceptibles} x100$$

Examples:

- High infectivity: Measles(infectivity more than 90%), Chickenpox
- Low infectivity: Leprosy

In example 1, if we assume there are 30 kids in the class: 20 are susceptible, 18 get measles, this is how we will measure the secondary attack rate:

$$Secondary\ attack\ rate = \frac{18}{20} x100 = 90\%$$

❖ Pathogenicity

- It is the ability of the organisms to produce specific clinical reaction after infection**.**
- It refers to the proportion of ***infected*** persons who develop clinical disease.

Examples:

- *High pathogenicity: Measles, Chickenpox (Class B)*
- *Low pathogenicity: Polio, Tuberculosis, Hepatitis A, Meningitis, AIDS (Class A)*

It can be measured by:

Ratio of clinical to sub-clinical case = $\frac{Clinical\ cases}{Subclinical\ cases}$

❖ Virulence

The ability of an infectious agent to cause severe disease, measured as the proportion of persons with the disease who become severely ill or die.

Examples: *Rabies, Hemorrhagic fevers caused by Ebola and Murberg viruses. (Class C)*

Virulence is measured by: **Case fatality rate**

$$\text{Case fatality rate} = \frac{\text{Total number of deaths from a disease}}{\text{Total number of cases of that disease}} x100$$

❖ Antigenicity (Immunogenicity)

It is the ability of the organism to produce specific immunity (antibodies or antitoxin).

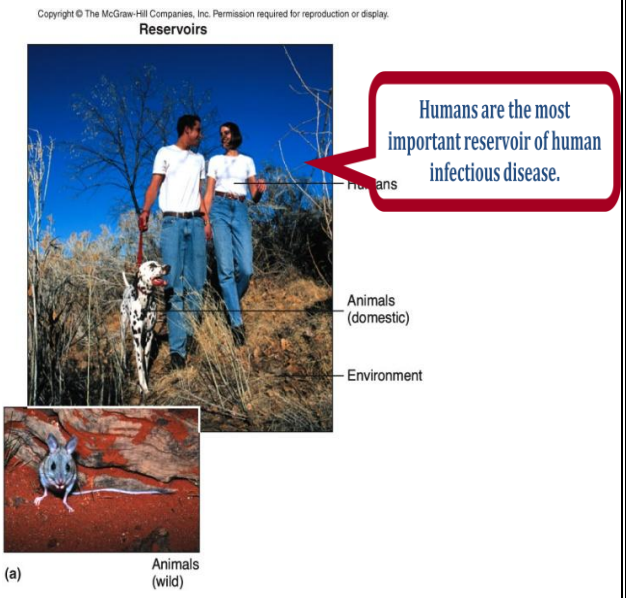
It can be measured by:

Second attack frequency:

- *Second attacks are rare in measles, mumps and chickenpox.*
- *Re-infection occurs as in case of common cold, syphilis and gonorrhea.*

2. Reservoir of infection

The **reservoir** of an agent is the *habitat* in which an infectious agent normally lives, grows, and multiplies.



Types of reservoirs:

- Humans (most common type)
- Animals
- Environment

Human reservoirs:

Two types of human reservoirs exist: case or carrier

1. **Case**: A person with symptomatic illness (patient to patient)
2. **Carrier:** A person that harbors the infectious agent for a disease and can transmit it to others, but <u>does not</u> demonstrate (show) signs of the disease.

- **Types of Carriers:**
  1. **Asymptomatic (In-apparent) carrier**: *Examples: Poliomyelitis, meningococcal meningitis, hepatitis A*
  2. **Incubatory, Convalescent, Post-Convalescent carriers:** The carrier state may occur during the incubation period, convalescence, and post convalescence of an individual with a clinically recognizable disease. *Examples of Incubatory carrier: Measles, chickenpox*
     Convalescence: the gradual recovery period after a disease/illness.

Types of carriers <u>according to duration</u>: The carrier state may be (transient carrier or chronic carrier).

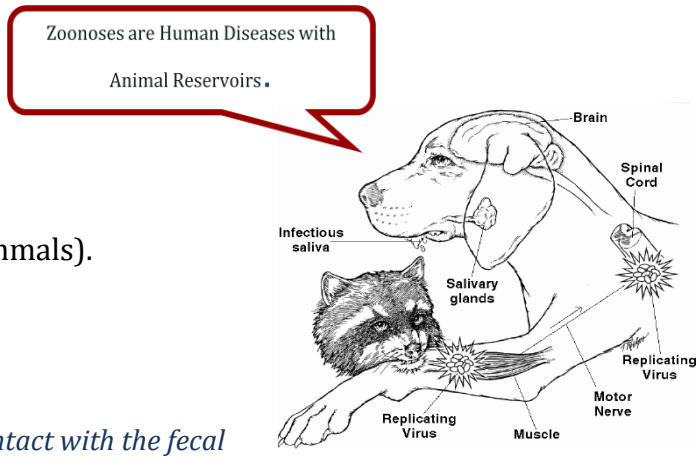
- **Chronic carriers:** They continue to harbour an agent for an extended time (months or years) following the initial infection. *Examples: Hepatitis B virus and Salmonella typhi*
  ** they are the ones that cause risk in the community*
- **Transient carrier:** harboring the agent for a short duration

Animal reservoirs

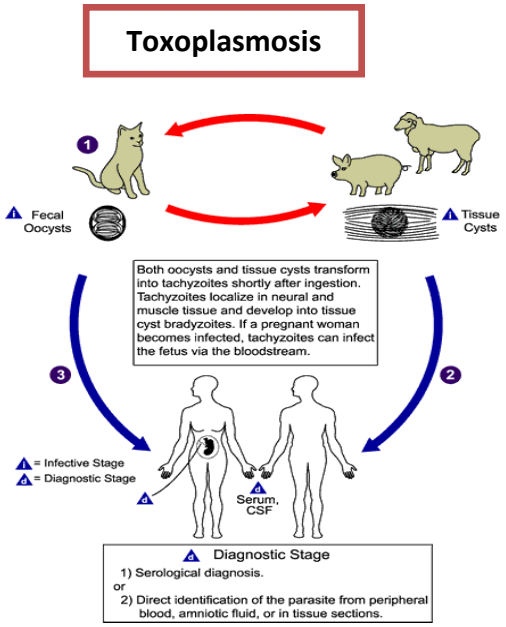
Zoonoses: An infection or infectious disease transmissible under natural conditions from vertebrate animals to humans

Zoonotic diseases include:

- brucellosis (cows and pigs),
- anthrax (sheep),
- plague (rodents),
- **Toxoplasmosis** (cats),
- rabies (bats, dogs, and other mammals).



Toxoplasmosis: if a pregnant woman is in contact with the fecal matter of a cat will have severe complications on the fetus, it can lead to miscarriage, still birth or if the baby lives many organs could be affected by it, most commonly the brain and eyes.



Environmental reservoirs: Soil, and water and plants

- Soil: Agents live and multiply in the soil.

Examples:

- **Tetanus** spores and Fungal agents; (those causing **histoplasmosis**) both live in the soil.
- Pools of water are the primary reservoir of **Legionnaires' bacillus**.

3. Portal of exit:

Portal of exit is the path by which an agent leaves the source host. *The portal of exit usually corresponds to the site where the pathogen is localized.*

Examples:

- Respiratory tract: influenza viruses and *Mycobacterium tuberculosis* exit the respiratory tract
- GIT
- Skin and mucous membrane *such as chicken pox*

4. Modes of transmission

• **Direct transmission**: There is essentially *immediate* transfer of the agent from a reservoir to a susceptible host

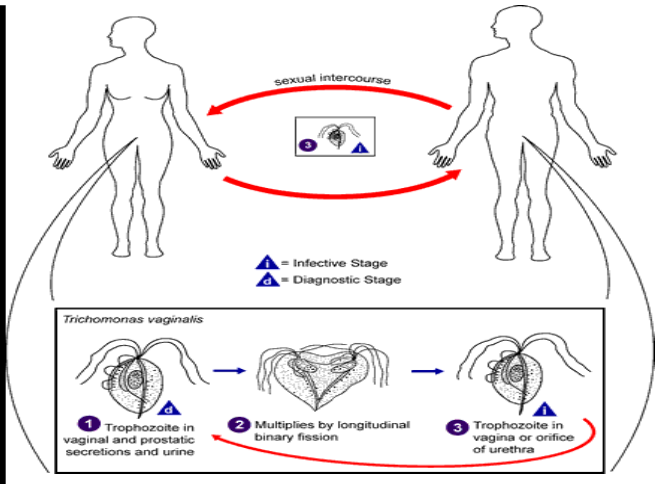
- **Direct contact:** *the reservoir must be in close contact, no barrier, for example: skin to skin contact, kissing, and sexual intercourse. It also refers to contact with soil or vegetation harbouring infectious organisms*
- **Droplet spread:** *refers to direct spray with relatively large, short-range aerosols produced by sneezing, coughing, or even talking. Droplet spread is classified as direct because transmission is by direct spray over a few feet, before the droplets fall to the ground.*

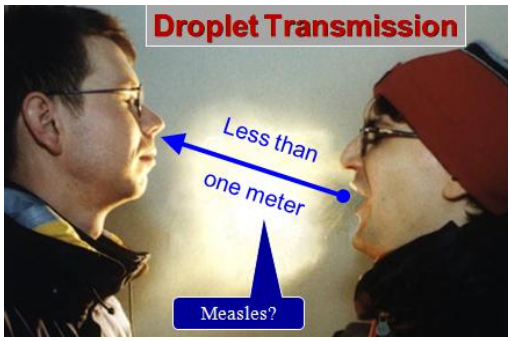
Pathogen Transmission

"The most frequently used medical instrument is your hand"

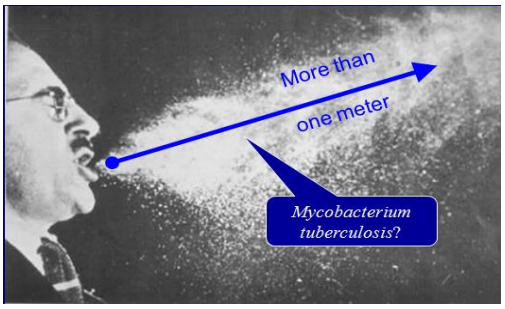
Rhinovirus?

Direct-Contact Transmission





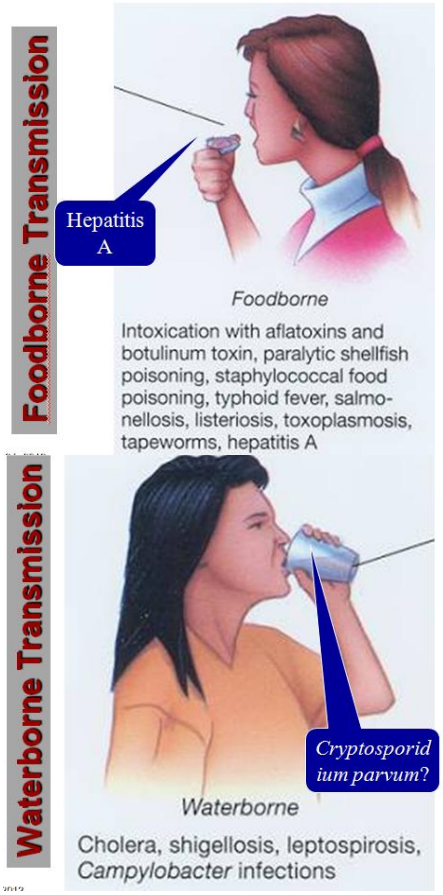
• **Indirect transmission**: An agent is carried from a reservoir to a susceptible host through



- **Airborne droplets** *suspended air particles (carried in air*).
  Examples:
  Tuberculosis is transmitted more often indirectly, through airborne transmission, than directly, through direct droplet spread.
  Legionnaires' disease and histoplasmosis also spread through airborne transmission.

- **Vehicle borne:** An infectious agent is carried from a reservoir to a susceptible host by an **in**animate intermediary.
  They include:

- Contaminated food and water, *typhoid, paratyphoid, food poisoning, dysentery and cholera.*
- Biologic products (blood), *viral hepatitis, AIDS, syphilis and malaria*.
- Fomites (inanimate objects such as: door knobs, toys, handkerchiefs, bedding, or surgical instruments).



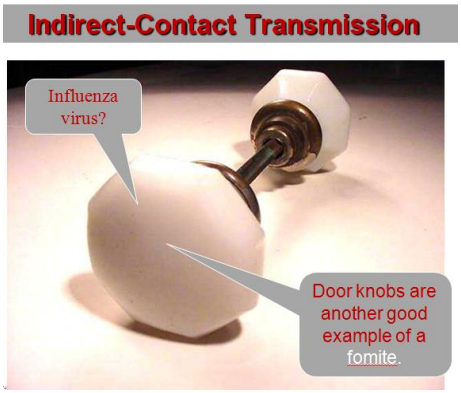
- **Vector borne:** Mechanical or Biologic. Animate vector which are arthropods such as mosquitoes, fleas, and ticks

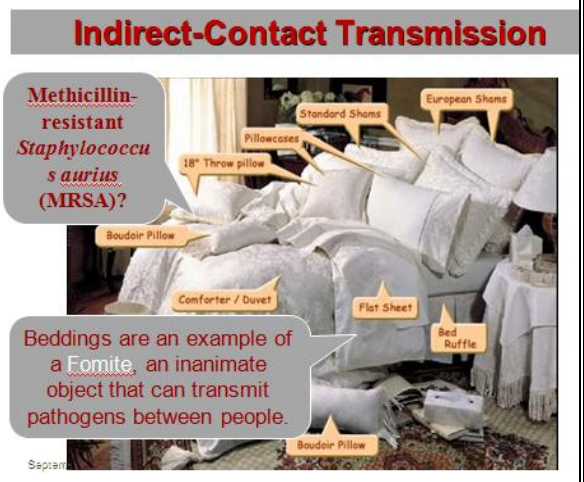
  - **Mechanical transmission:**

- The agent does not multiply or undergo physiologic changes in the vector.
- For example, flies carry *Shigella* on appendages.

  - **Biologic transmission:**

- When the agent undergoes changes and/or multiplication within the vector before it is transmitted.
- (*Extrinsic incubation period*). Example: Malaria, Filariasis. Extrinsic: inside the human's body





5. Portal of entry

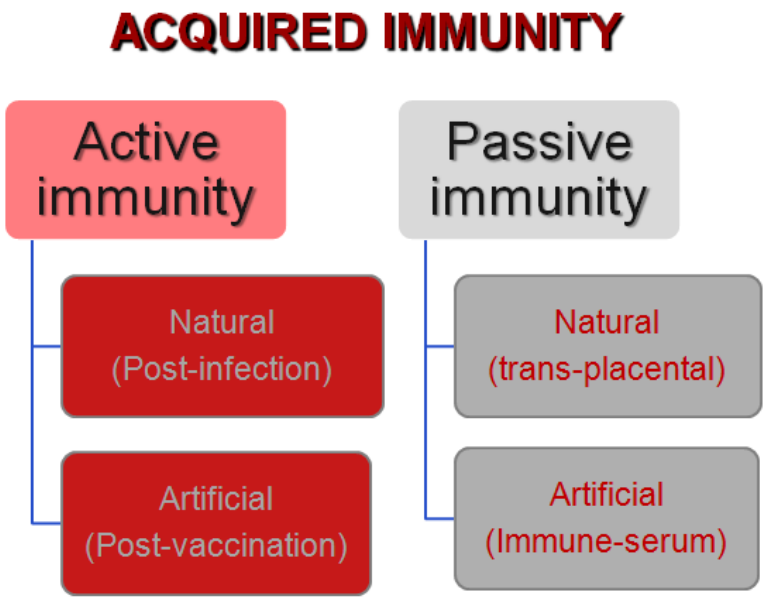
The portal of entry refers to the manner in which an agent enters a susceptible host.
– It must provide access to tissues in which the agent can multiply or a toxin can act.
- Often, organisms use the same portal to enter a new host that they use to exit the source host. For example, influenza virus exits the respiratory tract of the source host and enters the respiratory tract of the new host. In contrast, many pathogens that cause gastroenteritis follow a so-called "fecal-oral" route because they exit the source host in feces, are carried on inadequately washed hands to a vehicle such as food, water, or utensil, and enter a new host through the mouth. Other portals of entry include the skin (hookworm), mucous membranes (syphilis), and blood (hepatitis B, human immunodeficiency virus).

6. Host

A susceptible host is the final link in the chain of infection.
The host is a person or other living organism that are susceptible to (can be infected by) an infectious agent under normal conditions.
Susceptibility of a host depends on:

1. Genetic factors
2. General factors (nonspecific factors) such as diabetics, people who take chemotherapy or cortisol
3. Specific acquired immunity

Specific acquired immunity: specific antibodies that are mediated against specific agents. It refers to protective antibodies that are directed against a specific agent. Such antibodies may develop in response to infection, vaccine, or toxoid (toxin that has been deactivated but retains its capacity to stimulate production of toxin antibodies) or may be acquired by transplacental transfer from mother to fetus or by injection of antitoxin or immune globulin.



Specific acquired immunity: two types:

1. **Active immunity:** Resistance developed in response to stimulus by an antigen either;
   - **Naturally** by **infecting agent** (Post-Infection) example: H1N1
   - **Artificially** by **vaccine** (Post-Vaccination)

It is usually characterized by the presence of antibody produced by the host.

2. Passive immunity: Immunity conferred by an antibody produced in another host and may be acquired;

- **Naturally: transplacental immunity:** by an infant from its mother , stays for not more than 6 months
  Example: (Transplacental)
- **Artificially** by administration of an antibody containing preparation (immune-sera or immune globulin).

Herd immunity

It is the state of immunity of a group or a community.(collective immunity of the community, how many are immune)

Also it is "the resistance of a group to invasion and spread of an infectious agent, based on the immunity of a high proportion of individual members of the group".

Factors affecting herd immunity

- The extent of coverage of the immunization program (how many have been immunized).
- The degree of resistance to infection afforded by the vaccine(how many have post-infective immunity/natural immunity)
- Duration and degree of infectivity of the organism(H1N1 has a poor immunogenicity so after 6 months the same person would have lost the immunity, but measles have a strong immunogenicity thus the immunity stays for years).
- Past experience with different infections.
- Overcrowding and environmental sanitation. (low socioeconomic areas and people keep getting infections, epidemics and outbreaks due to overcrowding and bad sanitization, this causes the community to have many subclinical cases rather than clinical cases. But in communities of high economy people are more susceptible to be infected).

References

- Principles of **Epidemiology in Public Health Practice**. *Third Edition.* An Introduction to Applied Epidemiology and Biostatistics. Centers for Disease Control and Prevention (CDC)
- Porta M. **A dictionary of epidemiology.** 5th Edition. Oxford, New York: Oxford University Press, 2008.
- Gordis L. **Epidemiology.** 4th edition. Philadelphia, Pennsylvania: Elsevier Science, 2008
- Beaglehole R, Bonita R, Kjellstrom T. **Basic epidemiology.** 2nd edition. Geneva: World Health Organization, 2006