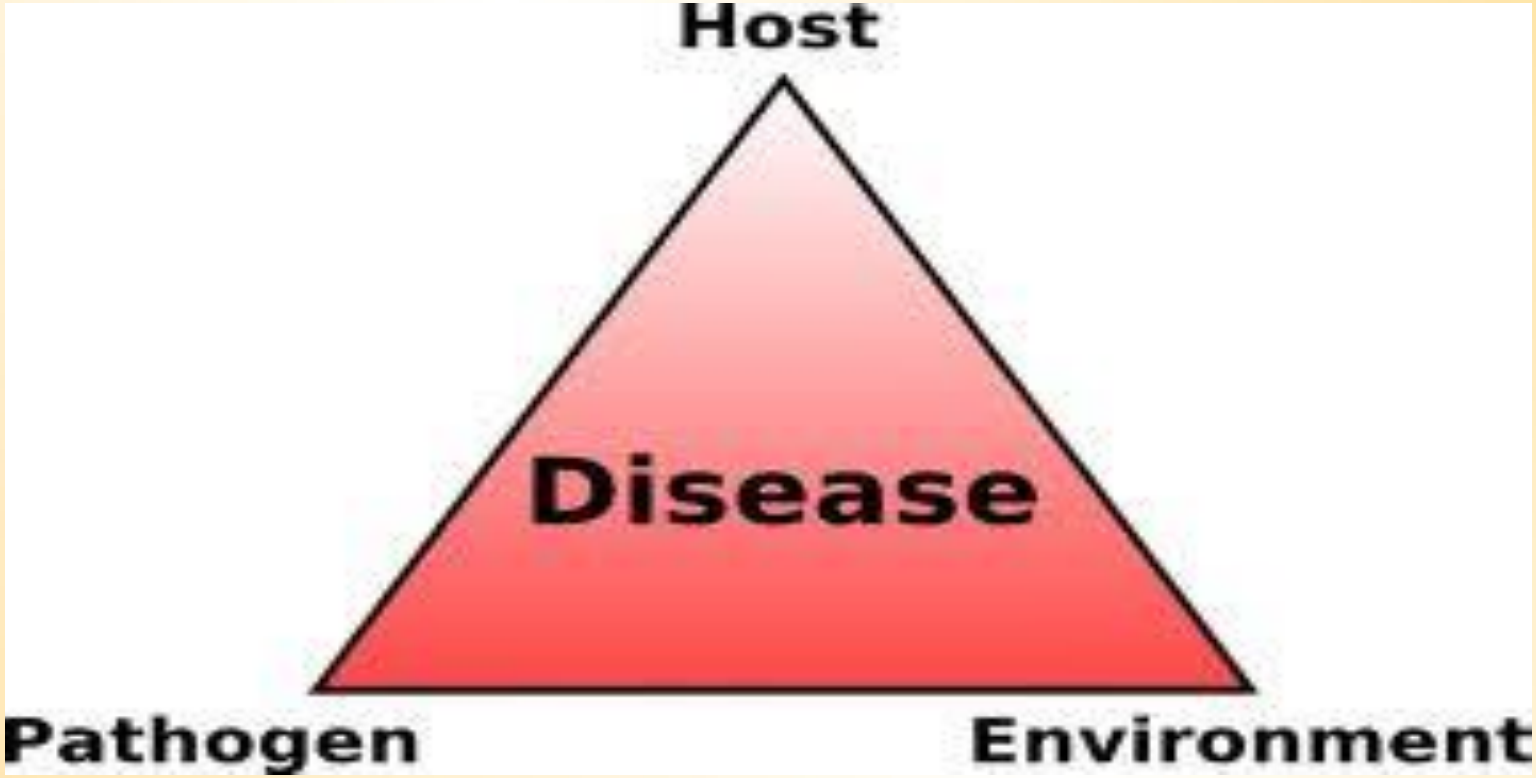
Principles of Communicable Diseases Epidemiology

PROF DR NAJLAA FAWZI

Infectious Disease Model



The cause often known

An infectious agent is a necessary cause

What is infectious disease epidemiology then used for?

- Identification of causes of new, emerging infections, e.g. HIV, vCJD, SARS
- Surveillence of infectious disease
- Identification of source of outbreaks
- Studies of routes of transmission and natural history of infections
- Identification of new interventions

IMPORTANCE OF STUDYING COMMUNICABLE DISEASES EPIDEMIOLOGY

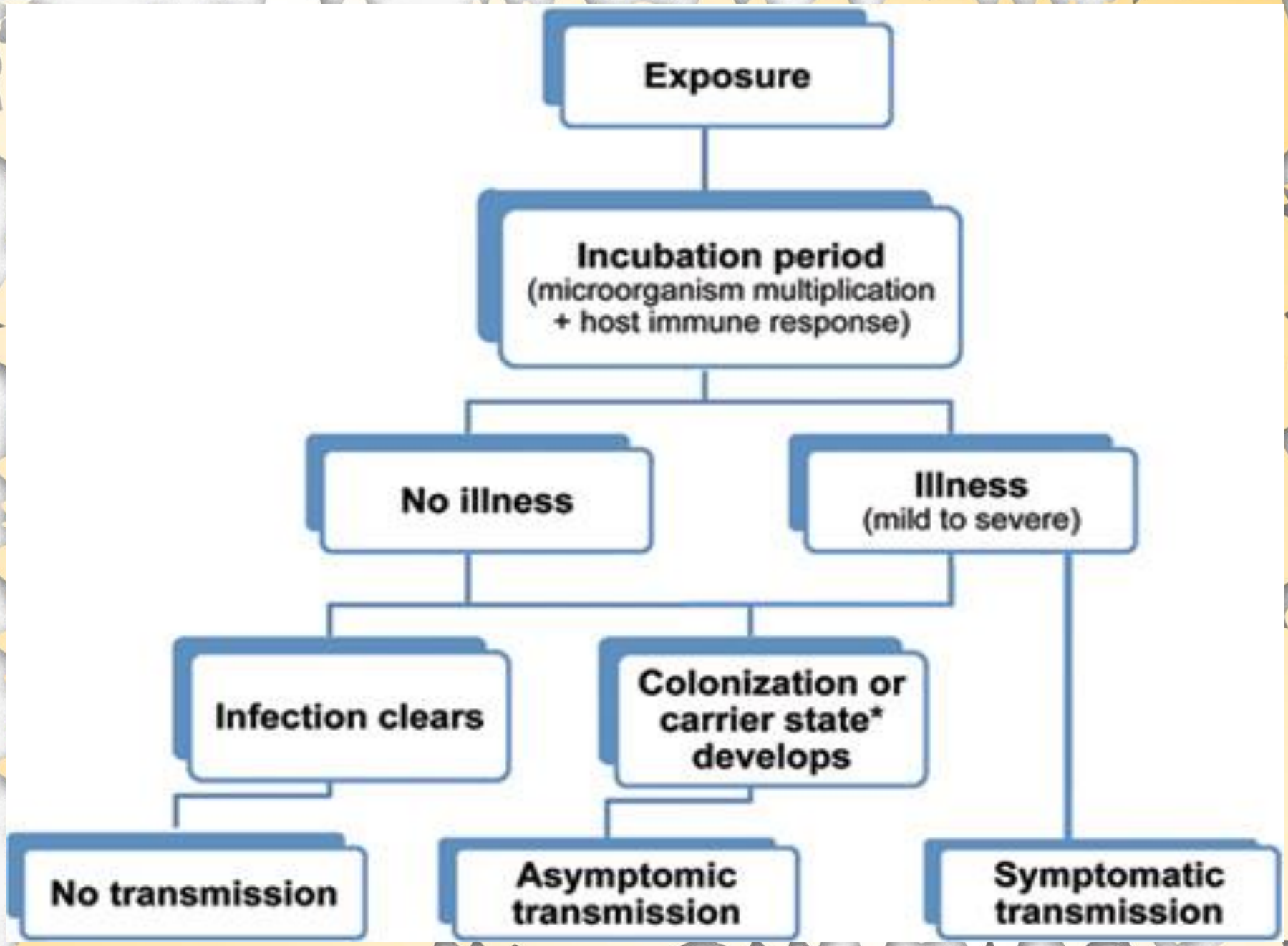
- **Changes of the pattern of infectious diseases**
- **Discovery of new infections**
- **The possibility that some chronic diseases have an infective origin.**
- **Communicable Diseases**

1- Continuous presence

2- Eradicated

3- Re-Emerging

4- Emerging (New)


Exposure
Incubation period
(microorganism multiplication
+ host immune response)
No illness
Illness
(mild to severe)
Infection clears
Colonization or
carrier state*
develops
No transmission
Asymptomic
transmission
Symptomatic
transmission

Infection

- **Infection is the entry and development or multiplication of an infectious agent in the body of man or animals.**

- **An infection does not always cause illness.**

- **There are several levels of infection (Gradients of infection):**

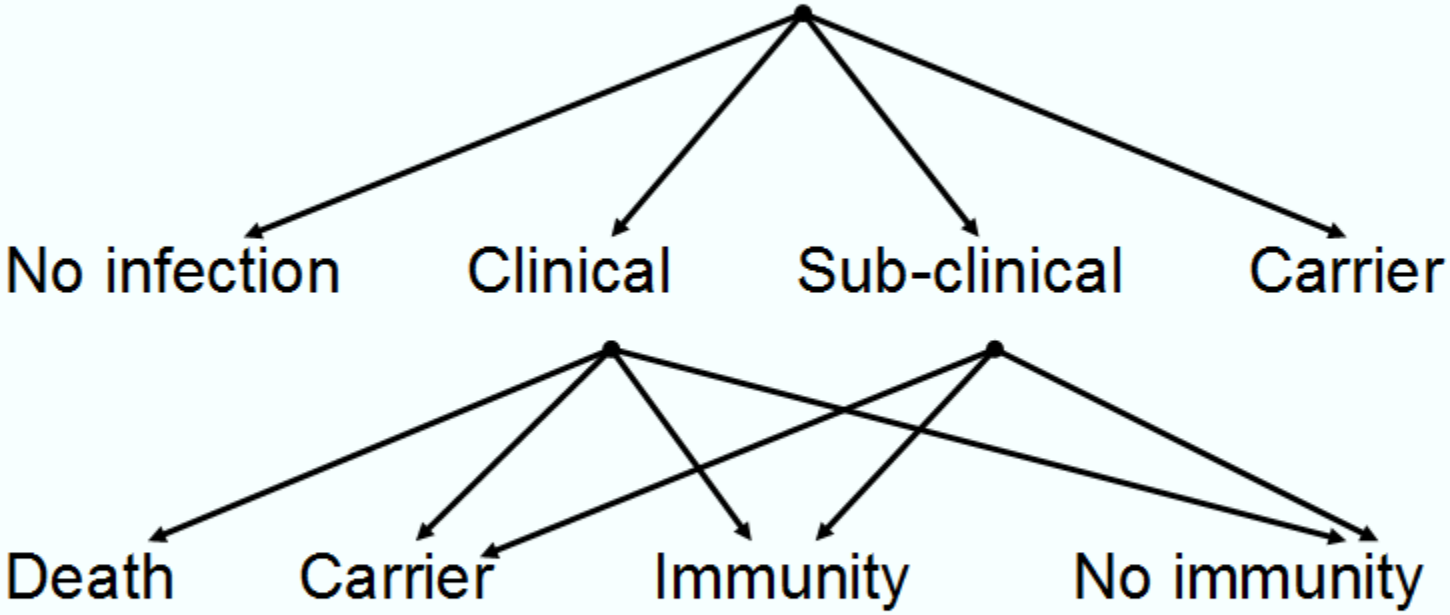
– Colonization (S. aureus in skin and normal nasopharynx)

– Subclinical or inapparent infection (polio)

– Latent infection (virus of herpes simplex)

– Manifest or clinical infection

Exposure to Infectious Agents



Outcome

(www)

WHAT ARE THE FACTORS INFLUENCE THE DEVELOPMENT OF SEVERAL LEVELS OF INFECTION ?

AGENT FACTORS

HOST FACTORS

1-AGENT FACTORS Are related to the:

Number (dose of infection)

Infectious dose (ID) is the amount of pathogen (measured in number of microorganisms) required to cause an infection in the host

Usually it varies according to the pathogenic agent and the consumer's age and overall health.

Infectious doses for some known microorganisms

Vibrio cholera	**relatively large (10_4 - 10_6 organisms)**
Ebola virus	**1 – 10 aerosolized organisms are sufficient to cause infection in humans**
Salmonella typhi	**100,000 organisms**

PATHOGEN CITY

Which is the property of an infectious agent that determines the extent to which obvious disease is produced in an infected population, or the power of organism to produce disease.

The ability to induce clinically apparent illness.

Pathogenicity: Number of diseased / Number infected

VIRULENCE

Means the speed with which an infectious agent kills the host.

The case fatality rate is one way of measuring virulence.

Case fatality rate for infectious diseases: is the proportion of infected individuals who die of the infection.

This is a function of the severity of the infection and is heavily influenced by how many mild cases are not diagnosed.

Virulence: Number of serious condition & mortality/ Number diseased

INVASIVENESS & TOXICITY

Invasiveness is the power of the organism to penetrate into the body fluids and tissues of the host to live and multiply.

TOXICITY

Could be defined as measure of ability of organism to affect clinical reaction by chemical substances which it produces.

Toxins produce by pathogens are either retained within their bodies and liberated after disintegration of the organisms, and are called ENDOTOXIN; or are released during the life of the organisms and are called EXOTOXIN.

TISSUE SELECTIVITY (TROPISM)

It is the inherent capacity of pathogens to invade some particular tissues.

This is the factor that give each disease its characteristics symptoms & signs.

ANTIGENIC CHARACTER AND ANTIGENICITY

Antigenicity is measure of ability of organism to stimulate an immunologic response in the host.

VIABILITY

The viability of pathogen is the ability to live and the period of living outside the body.

SUSCEPTIBILITY TO CHEMOTHERAPY AND ANTIBIOTICS

HOST FACTORS IN CAUSATION OF DISEASE

The HOST is defined as " Any susceptible man or animal potentially exposed to be parasitized by infective organisms".

The host factors in causation of diseases are factors ,specific for the host , governing the occurrence , type, spread or severity of infection .

THEY INCLUDE :

- Resistance & immunity
- Genetic factors
- Social & habitual factors
- Physiological factors
- Age factors
- Sex factors

CONTAGIOUS DISEASE

- **A contagious disease is the one that is transmitted through contact. Examples include scabies, trachoma, STD and leprosy.**

COMMUNICABLE DISEASES

- **A communicable disease is an illness due to a specific infectious (biological) agent or its toxic products capable of being directly or indirectly transmitted from man to man, from animal to man, from animal to animal, or from the environment (through air, water, food, etc..) to man.**

CONTAMINATION

- **The presence of an infectious agent on a body surface, on or in clothes, beddings, toys, surgical instruments or dressings, or other articles or substances including water and food.**

LATENT INFECTION

- **The host doesn't shed the infectious agent which lies dormant within the host without symptoms. Ex., latent infection occurs in herpes simplex.**

IN APPARENT INFECTION

The presence of infection in a host without recognizable clinical signs or symptoms.

In apparent infections are identifiable only by laboratory means such as a blood test or by the development of positive reactivity to specific skin tests.

INCUBATION AND LATENT PERIODS

- **Incubation period:** time from exposure to development of disease. In other words, the time interval between invasion by an infectious agent and the appearance of the first sign or symptom of the disease in question.

- **Latent period:** the period between exposure and the onset of infectiousness (this may be shorter or longer than the incubation period).

Incubation period of a disease is useful for:

- Tracing the source of infection and contacts
- Determining the period of surveillance
- Applying immunization principles for prevention of diseases
- Identification of point source or propagated epidemics
- Estimating prognosis of a disease

The factors which determine the incubation period

- The generation time of the pathogen
- Infective dose
- Portal of entry
- Individual Susceptibility

Median incubation period:

The time required for 50% of the cases to occur following exposure.

Period of communicability: is the time during which an infectious agent may be transferred directly/indirectly from an infected person to another person, from infected animal to man or from an infected person to animal, including arthropods.

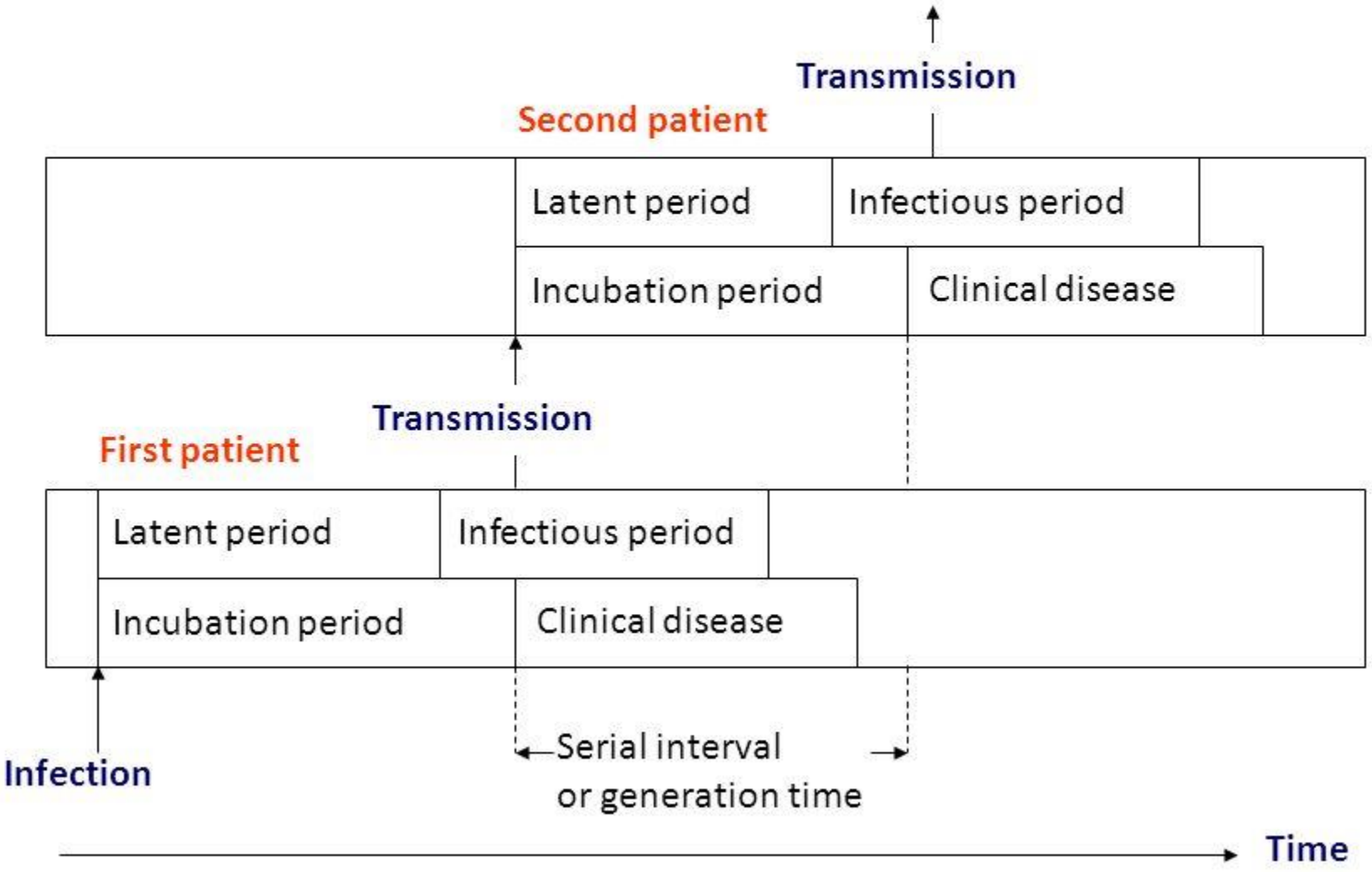
– An important measure of communicability is secondary attack rate

Infectious (communicable) period: length of time a person can transmit disease (sheds the infectious agent).

Serial interval and Infectious period

- **Serial interval:** (the gap in time between the onset of the primary and the secondary cases) the interval between receipt of infection and maximal infectivity of the host (also called generation time).
- Serial interval, time between generations of disease.
- Time between similar symptoms in successive generations.

Relationships between time periods



Reproductive rate of infection

- ✓ **Reproductive rate of infection: potential for an infectious disease to spread.**
- ✓ **Influential factors include:**
  - **The probability of transmission between an infected and a susceptible individual**
  - **Frequency of population contact**
  - **Duration of infection**
  - **Virulence of the organism**
  - **Population immune proportion**

The basic reproductive rate (R_o)

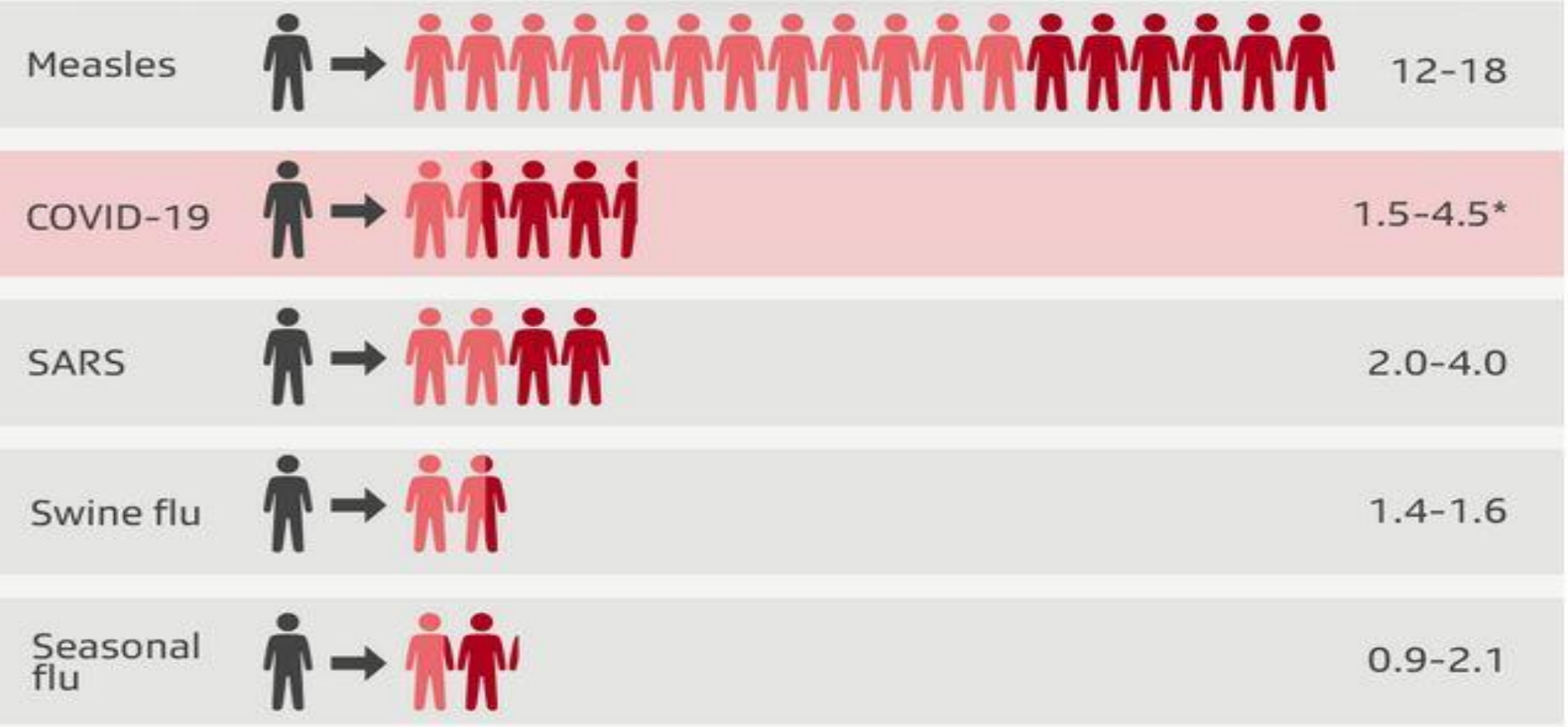
The basic reproduction number (R_0), also called the basic reproduction ratio or rate or the basic reproductive rate, is an epidemiologic metric used to describe the contagiousness or transmissibility of infectious agents. R_0 is affected by numerous biological, sociobehavioral, and environmental factors that govern pathogen transmission

R 0 the average number of persons infected by a single disease source.
In other words, this is the number of expected secondary infections resulting from a single infectious case.

- **Another way to explain Ro is the number of people who are expected to be infected by one person who has the disease in question.**

Infection rate

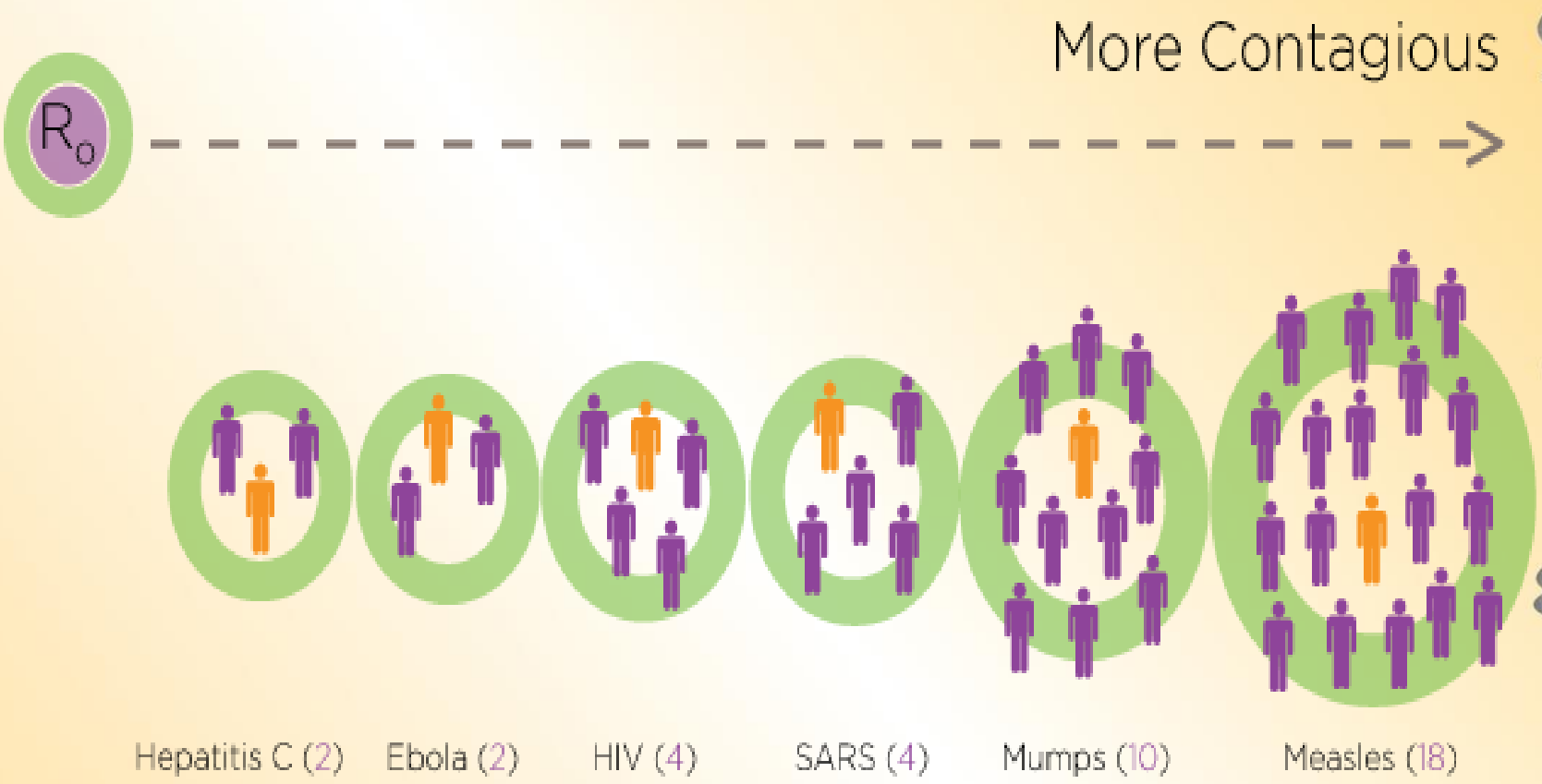
The average number of people an ill person infects



*according to data from Wuhan

Source: Estimates from the WHO, the CDC, the London School of Hygiene and Tropical Medicine and various studies

SWI


More Contagious
R_0
Hepatitis C (2)
Ebola (2)
HIV (4)
SARS (4)
Mumps (10)
Measles (18)

This rate is affected by several factors including:

- **The duration of infectivity**
- **The infectiousness of the organism**
- **The number of susceptible people with whom the infected patient comes in contact**

In general, if Ro is greater than one, the disease will continue to spread within a population. If Ro is less than one, the disease will eventually disappear from a population.

If the R value is higher than one, then the number of cases increases exponentially - it snowballs like debt on an unpaid credit card.
But if the R number is lower the disease will eventually stop spreading, because not enough new people are being infected to sustain the outbreak.

If R_o = 1 then approximately the same number of individuals are infected with every new generation causing endemicity.

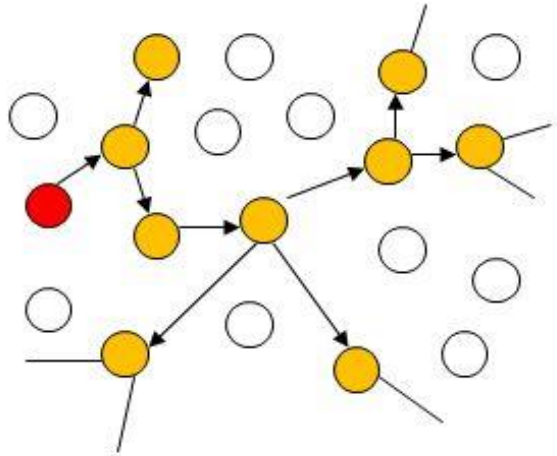
If R_o > 1 then there is a constantly increasing number of infected individuals.

Larger R

- is associated with greater contact rate (greater population density)
- greater duration of infectiousness or probability of transmission per contact (greater infectiousness)
- Larger R is associated with lower average age at infection

Basic reproductive rate (R_0)

- Average number of individuals directly infected by an infectious case (secondary cases) during her or his entire infectious period, when she or he enters a totally susceptible population
- (1+2+0+1+3+2+1+2+1+2)/10 = 1.5
  - $R_0 < 1$ - the disease will disappear
  - $R_0 = 1$ - the disease will become endemic
  - $R_0 > 1$ - there will be an epidemic



Basic reproductive rate (R_0)

Basic formula for the actual value: $R_0 = \beta * \kappa * D$

- **β** - risk of transmission per contact (i.e. attack rate)
  - Condoms, face masks, hand washing → β ↓
- **κ** - average number of contacts per time unit
  - Isolation, closing schools, public campaigns → κ ↓
- **D** - duration of infectiousness measured by the same time units as κ
  - Specific for an infectious disease
  - Early diagnosis and treatment, screening, contact tracing → D ↓

Transmission Probability Ratio (TPR)

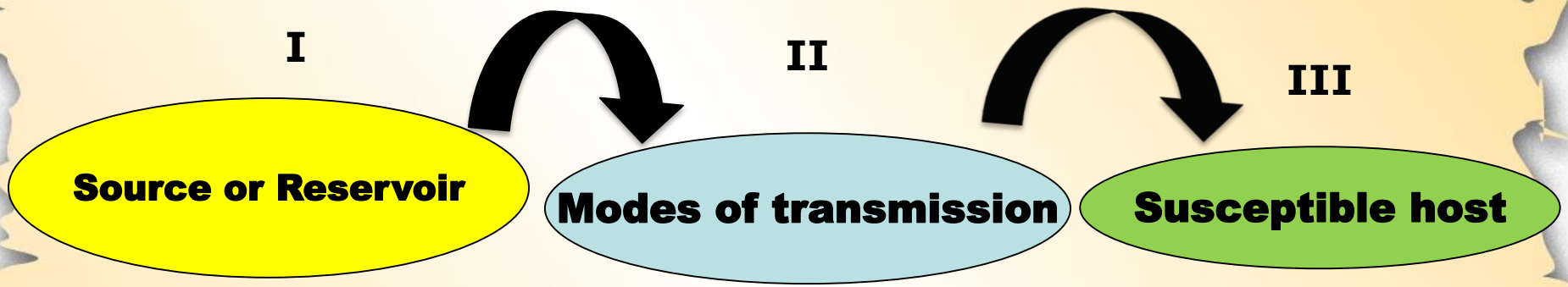
- **TPR is a measure of risk transmission from infected to susceptible individuals during a contact.**
- **TPR of differing types of contacts, infectious agents, infection routes and strains can be calculated.**
- **There are 4 types of transmission probabilities.**

Transmission probabilities:

- ✓ **p00: t p from unvaccinated infective to unvaccinated susceptible**
- ✓ **p01: t p from vaccinated infective to unvaccinated susceptible**
- ✓ **p10: t p from unvaccinated infective to vaccinated susceptible**
- ✓ **p11: t p from vaccinated infective to vaccinated susceptible**

- **To estimate the effect of a vaccine in reducing susceptibility, compare the ratio of p10 to p00.**
- **To estimate the effect of a vaccine in reducing infectiousness, compare the ratio of p01 to p00.**
- **To estimate the combined effect of a vaccine, compare the ratio of p11 to p00.**

Dynamics of disease Transmission (Chain of Infection)



FACTORS FOR DEVELOPMENT OR SPREAD OF INFECTIOUS DISEASE

- An etiological **AGENT** responsible for the disease should be present.
- There should be a **RESERVOIR** or carrier for the etiological agent to survive (**SOURCE**)
- The infecting agent should be able to ESCAPE from the reservoir of infection through the **PORTAL OF EXIT**
- There should be a possible source of ENTRY to transmit the agent to a new **SUSCEPTIBLE HOST**
- The agent should be able to INVADE the new host
- The host should be susceptible

SOURCE & RESERVOIR

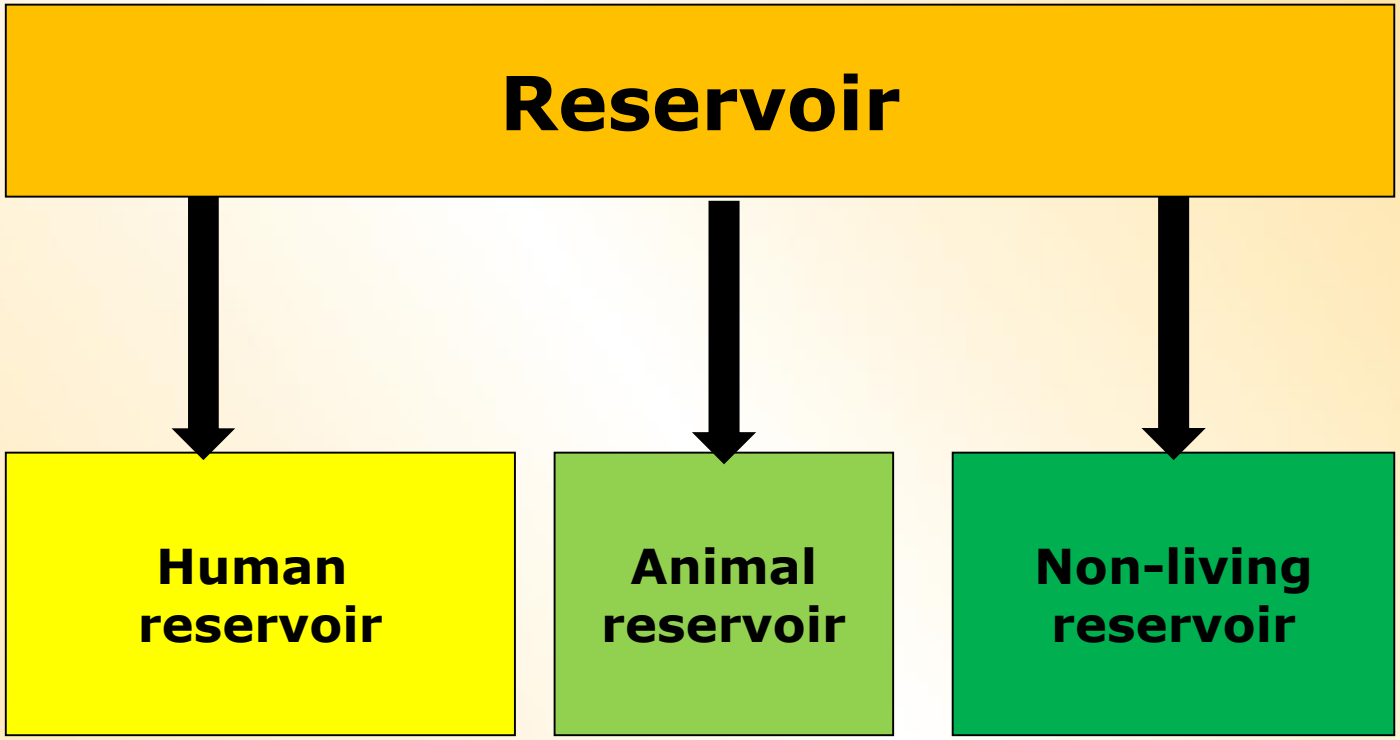
The starting point for the occurrence of a communicable disease is the existence of a reservoir or source of infection.

The source of infection is defined as “the person, animal, object or substance from which an infectious agent passes or is disseminated to the host (immediate source).

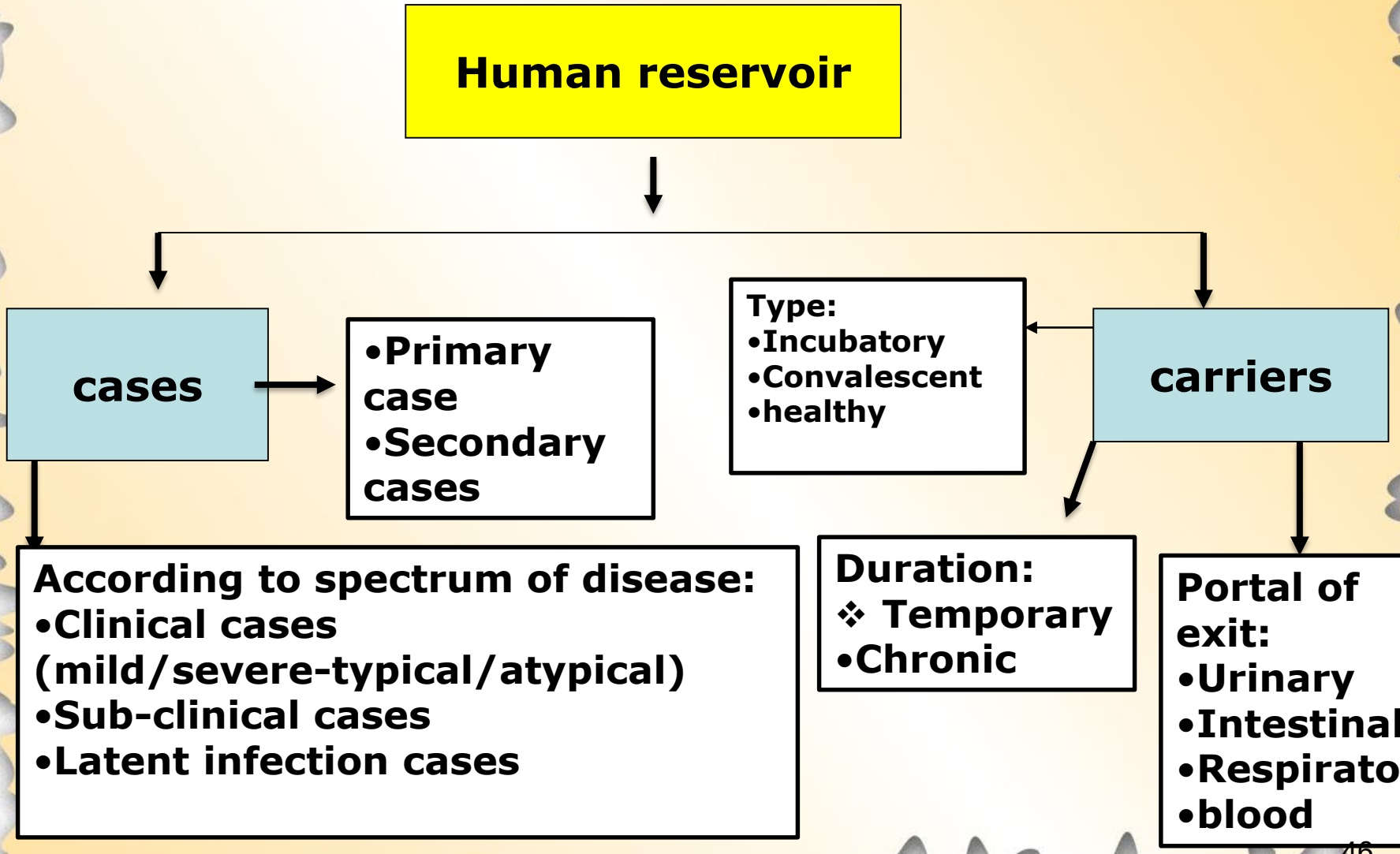
- **Reservoir** is defined as “any person, animal, arthropod, plant, soil, or substance (or combination of these) in which an infectious agent lives and multiplies, on which it depends primarily for survival, and where it reproduces itself in such manner that it can be transmitted to a susceptible host”.

- In short, it is the natural habitat of the organism.

Types of reservoirs



HUMAN RESERVOIR



Cases

- **A case is defined as "a person in the population or study group identified as having the particular disease, health disorder, or condition under investigation". The case may be clinical, subclinical, or latent.**

Cases shows manifestation of disease, are infectious for varied period of time, according to the nature of disease, and whether specific therapy available and given or not.

Some days only – Influenza, common cold, measles.

Some weeks or few months – Pertussis, viral hepatitis (all types)

Long period of infectivity – chronic infectious diseases as syphilis, AIDS, TB, B, C hepatitis.

Cases in Epidemiology

Primary case

- Refers to the first case of a communicable disease introduced into the population.

Secondary cases

- Are those developing from contact with primary case

- **Index case:** First case that comes to the notice of the investigator (first case reported to the health system)

CARRIERS:

A carrier is an apparently healthy person who is infected and harbors a pathogenic organism in his body, with out showing the manifestations of disease, but can spread infection.

It occurs either due to inadequate treatment or immune response, the disease agent is not completely eliminated, leading to a carrier state.

Mary Mallon (a.k.a. Typhoid Mary) was an asymptomatic carrier of typhoid fever. Over the course of her career as a cook, she infected 53 people, three of whom died.

Three elements have to occur to form a carrier state:

1. **The presence of the disease agent in the body .**
2. **The absence of recognizable symptoms and signs of disease.**
3. **The shedding of disease agent in the discharge or excretions.**

Types of carriers

Based on health status

1. Incubatory Carriers

- They are those who shed the infectious agent during

The I.P.

- It usually occurs during the last few days of the I.P
- At the end of I.P these carriers become case
- Example:Measles, mumps, polio, pertussis,influenzia,

Diphtheria,Hepatitis B

2-Convalescent carriers

- These are those who continue to shed disease agent during the period of convalescence

- This means person is cured clinically , but not Bacteriologically.

- Examples :Typhoid fever, cholera, diphtheria

- A convalescent carrier poses a serious threat to the unprotected household members and those in the immediate environment.

3- Healthy carriers: are victims of subclinical Infection, who developed carrier state without suffering obvious disease .

Example: polio, cholera, meningococcal meningitis

By Duration

1. Temporary carriers

These are those shed the infectious agent for short period : incub carrier, convalescent and healthy carriers

2- Chronic carriers

- These are those who excrete the agent for indefinite periods
- Example : typhoid fever, hepatitis B, AIDS**

By porta of exit

I. Urinary carriers-typhoid
II. Intestinal carrier - typhoid, polio
III. Biliary carriers- typhoid
IV. Cutaneous carriers – staphylococci
V. Nasal carriers – as in nasal diphtheria
VI. Genital carriers- as in gonorrhea, AIDS

Why carriers are important from epidemiology point of view ?

FOCI OF COMMENSALS???

ANIMAL RESERVOIRS

- **Zoonosis is an infection that is transmissible under natural conditions from vertebrate animals to man, e.g. rabies, plague, bovine tuberculosis.....**

- **There are over a 100 zoonotic diseases that can be carried from animal to man.**

RESERVOIR IN NON-LIVING THINGS

Soil, water, and food can be **nonliving reservoirs of infection**:

- **Soil**, especially if **fecally contaminated**, can harbor *Clostridium* bacteria, which cause **botulism, tetanus**, and other diseases.

- **Water** can be **contaminated** with **feces** and **urine** containing **parasitic worm eggs**, pathogenic **protozoa**, **bacteria**, and **viruses**.

- **Meats** and **vegetables** can also harbor pathogens.

- **Milk** can contain **many pathogens**, which is why it is routinely **pasteurized** in developed countries.