Principles of Communicable Diseases Epidemiology-L-1/22-23

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Objectives

- **Ascertain the importance of studying communicable diseases epidemiology**
- **Learn common terminology in communicable diseases epidemiology**
- **Define dynamics of disease transmission (chain of infection): Types of reservoir /source of infections**

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.**

Why Communicable Diseases are important to any health system?

1- Continuous presence -Cholera
2- Eradicated -Small pox
3- Re-Emerging- TB, Monkey pox
4- Emerging (New) -Covid-19

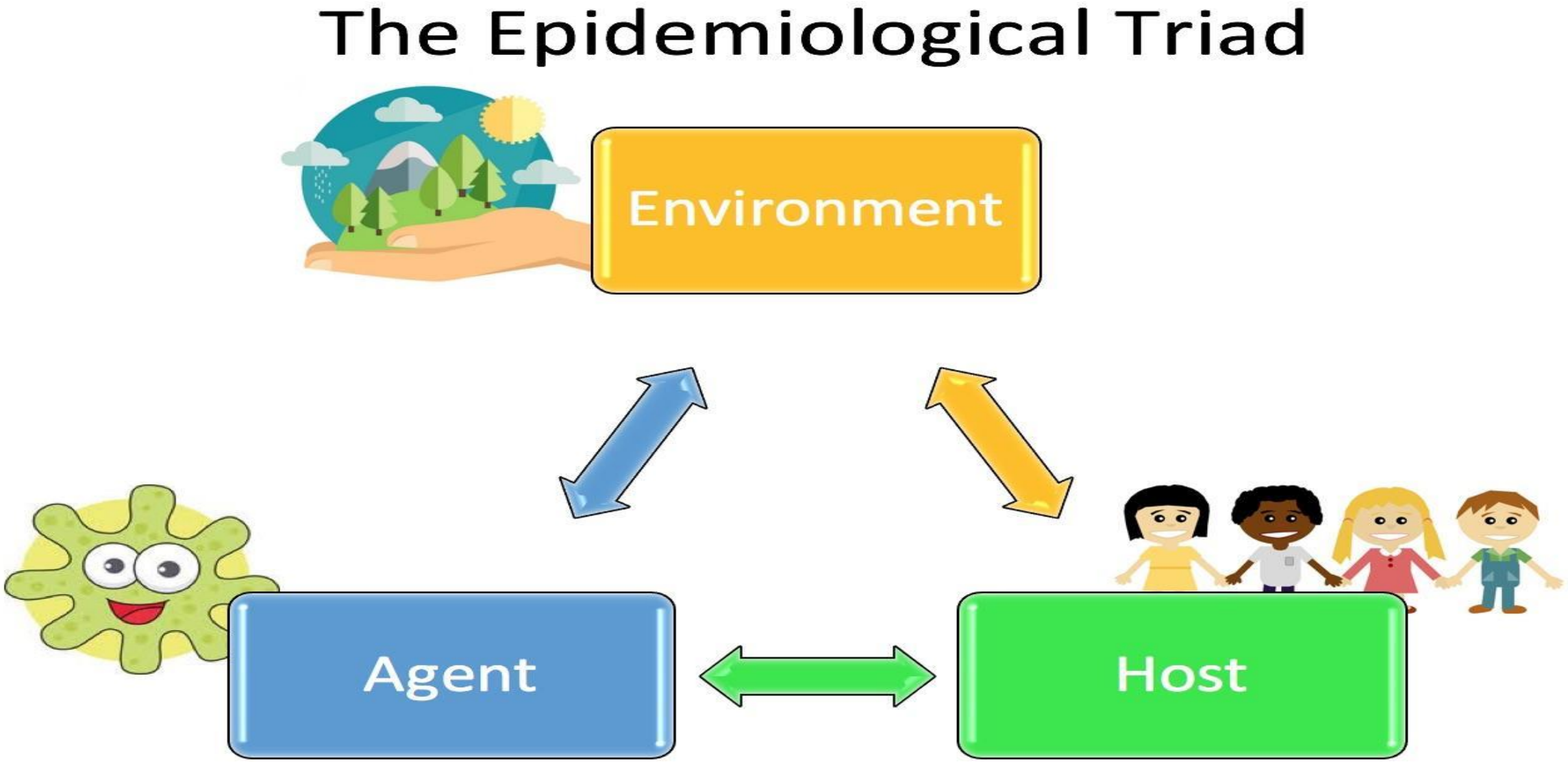
REASON FOR CHANGES IN PATTERN OF INFECTIOUS DISEASES?

1-This might be due to improvement in nutrition, better sanitation and housing, immunizations and antimicrobial chemotherapy.

2-Infections such as diphtheria, poliomyelitis and tetanus have decreased and, in some locations, have almost disappeared due to immunization.

3-Smallpox, has been eradicated from the world while another lethal infection, human immunodeficiency virus (HIV), H5N1 and Covid 19 had emerged in pandemic proportions.

Infectious Disease Model



Infection

- **Complex process of interaction between pathogen and human body**

- **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 (Grades 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

What are the factors influence the development of several levels of infection ?

1- Agent Factors
2- Host Factors

- **AGENT FACTORS: are related to**

1-Number (dose of infection) Infectious dose (ID)

Is the estimated number of organisms or virus particles required to produce infection in 50% of normal adult humans exposed by a given route.

Usually it varies according to the pathogenic agent and the individual age and overall health.

Table 1. Infectious Dose of Select Bacterial Foodborne Pathogens (based on Matthews et al. 2017)

Intoxication		
Organism	**Toxin**	**Infectious dose**
Bacillus cereus	Emetic toxin (cyclic peptide)	10^5 to 10^8 cells per g
Clostridium botulinum	Neurotoxins	LD_{50} of 0.4 ng/kg of (monkey) body weight LD_{50} of 0.000000001 (1×10^9) oz for a 150-lb human
Staphylococcus aureus	Enteroxins	1–5 μg of ingested toxin (outbreak) 10^5 to 10^8 cells per g
Toxicoinfection		
Organism	**Toxin**	**Infectious Dose**
Bacillus cereus	Enterotoxins (protein)	10^5 to 10^7 cells (total)
Clostridium perfringens	*Clostridium perfringens* enterotoxin (CPE)	10^5 cells per g
Infection		
Organism		**Infectious Dose**
Campylobacter jejuni		<500 cells
Escherichia coli O157:H7		<100 cells
Listeria monocytogenes		>100 cell g (outbreaks) LD_{50} of 10^3 to 10^7 cells (mice)
Salmonella spp.		10^0 to 10^{11} cells
Shigella spp.		~100 cells
Vibrio parahaemolyticus		10^5 to 10^7 cells (human volunteer studies and epidemiological information)
Yersinia enterocolitica		Likely >10^4 cells

Virus	Particle-to-PFU ratio
Adenoviridae	20–100
Alphaviridae	
Semliki Forest virus	1–2
Herpesviridae	
Herpes simplex virus	50–200
Orthomyxoviridae	
Influenza virus	20–50
Papillomaviridae	
Papillomavirus	10,000
Picornaviridae	
Poliovirus	30–1,000
Polyomaviridae	
Polyomavirus	38–50
Simian virus 40	100–200
Poxviridae	1–100
Reoviridae	
Reovirus	10

2-pathogeni city

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

3-VIRULENCE

Means the speed with which an Infectious agents kills the host.

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

The case fatality rate is one way of measuring the virulence.

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

Virulence: Number of serious condition & mortality/ Number diseased

4-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 is produces.

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

5-Tissue Selectivity (Tropism)

It is the inherent capability of pathogens to Invade some particular tissues

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

6-Antigenic Character &Antigenicity

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

7-Viability

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

8-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".

A person or other animal, including birds & arthropods, that affords subsistence or lodgement to an infectious agent under natural conditions

- **Primary (definitive) host**
- **Secondary (intermediate) host**

The host factors in causation of diseases are factors specific for the host , and important for :

- **Occurrence**
- **Type**
- **Spread**
- **Severity of infection**

They include :

- **Resistance & immunity**
- **Genetic factors**
- **Physiological factors**
- **Age factors**
- **Sex factors**

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.

Contagious disease

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

- **All contagious diseases are infectious, but not all infectious diseases are contagious. Contagious diseases are infectious diseases that are easily spread through contact with other people.**

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 development of positive reactivity to specific skin tests.

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.

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).

- **Generation time:** is the time taken for a person from receiving of infection to develop maximum infectivity.

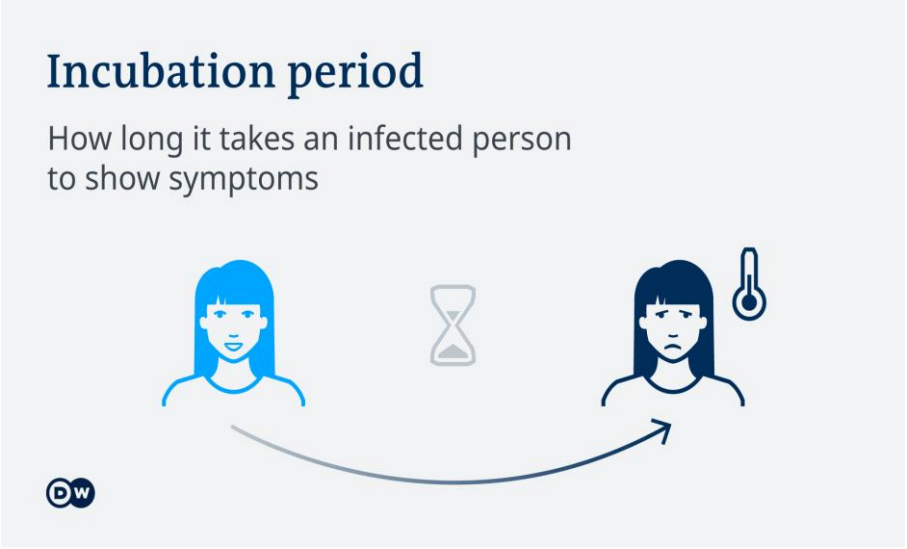
Is roughly equal to the incubation period of the disease.

- **Median incubation period:**

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

The factors which determine the incubation period

- ❑ **The generation time of the pathogen**
- ❑ **Infective dose**
- ❑ **Portal of entry**
- ❑ **Individual susceptibility**



Disease	Incubation period (days)[a]
Influenza	1–2
Common cold	1–3
Bronchiolitis, croup	3–5
Acute respiratory disease (adenoviruses)	5–7
Dengue	5–8
Herpes simplex	5–8
Enterovirus disease	6–12
Poliomyelitis	5–20
Measles	9–12
Smallpox	12–14
Chickenpox	13–17
Mumps	16–20
Rubella	17–20
Mononucleosis	30–50
Hepatitis A	15–40
Hepatitis B and C	50–150
Rabies	30–100
Papilloma (warts)	50–150
AIDS	1–10 yr

[a]Until first appearance of prodromal symptoms.

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 period of infectivity is the time that the patient is infectious to others.

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

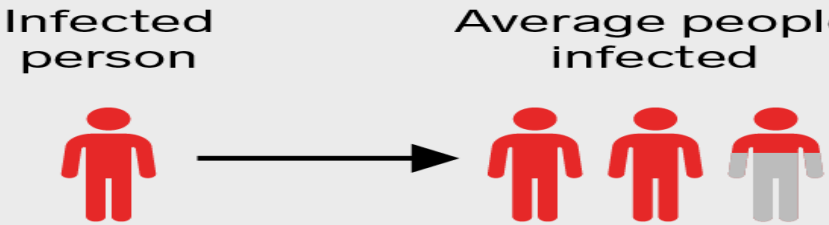
- An important measure of communicability is secondary attack rate

An infection rate : **is the probability or risk of an infection in a population. It is used to measure the frequency of occurrence of new cases of infection within a population during a specific time period.**

The number of infections equals the cases identified in the study or observed.

The average number of people that one person with a virus infects, based on the R0 scale

COVID-19: 2—2.5*



H1N1: 1.2—1.6

Ebola: 1.6—2

SARS: 2—4

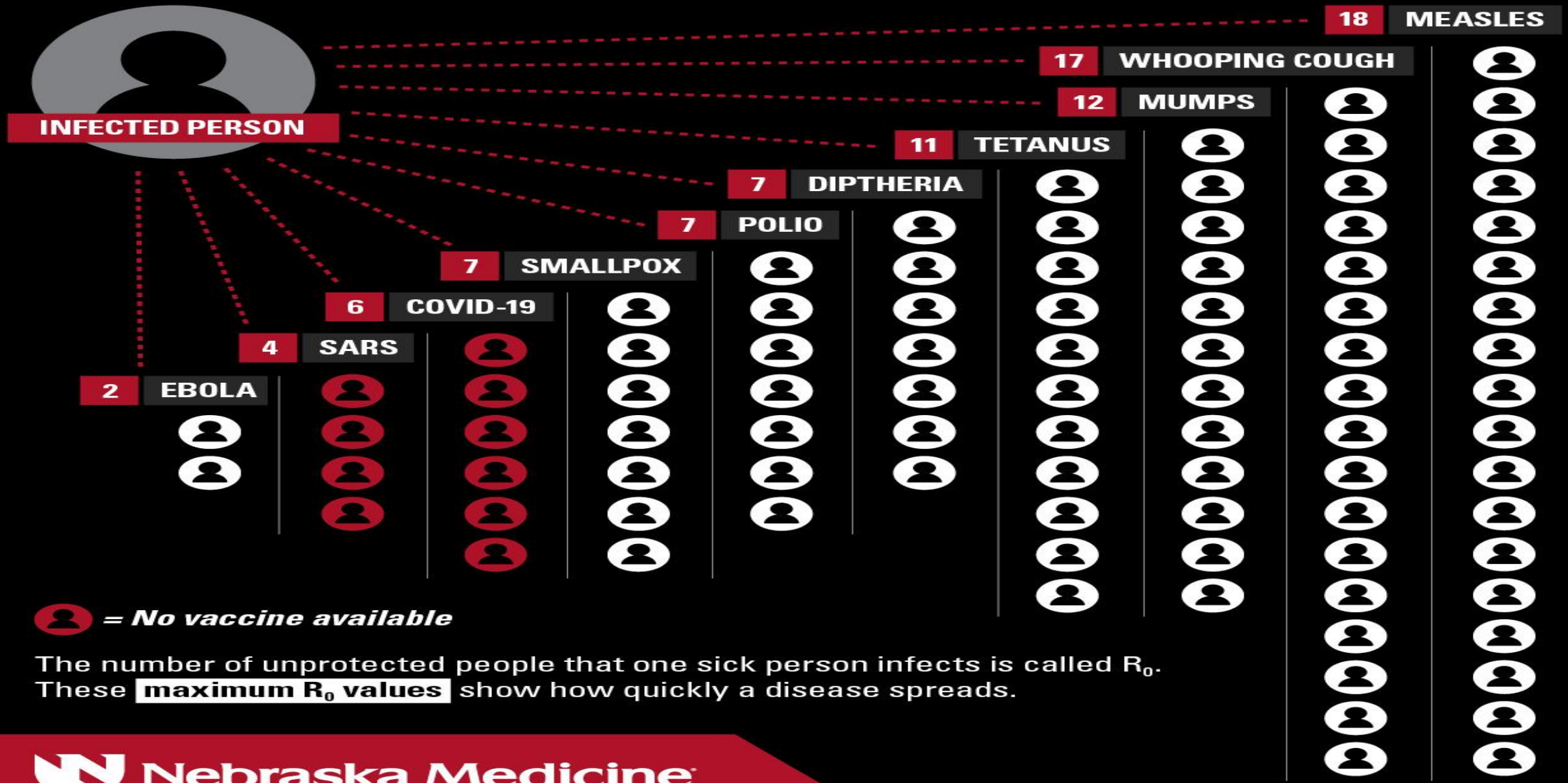
MERS: 2.5—7.2**

*As of February 28, 2020 **R0 calculated solely during the 2015 outbreak in South Korea

Sources: ScienceMag; WHO; Journal of the ISIRV

BUSINESS INSIDER

How quickly does a disease spread?



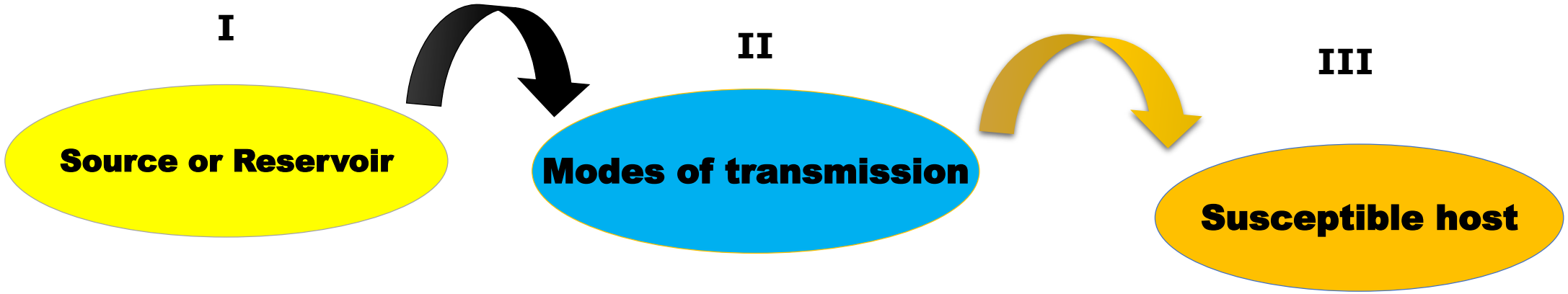
= *No vaccine available*

The number of unprotected people that one sick person infects is called R_0. These **maximum R_0 values** show how quickly a disease spreads.

Nebraska Medicine

Sources: CDC, LiveScience, EID Journal, and medRxiv.

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

Chain of Infection

Next Sick Person

(Susceptible Host)

- Babies
- Children
- Elderly
- People with a weakened immune system
- Unimmunized people
- Anyone

Germs

(Agent)

- Bacteria
- Viruses
- Parasites

How Germs Get In

(Portal of Entry)

- Mouth
- Cuts in the skin
- Eyes

Where Germs Live

(Reservoir)

- People
- Animals/Pets (dogs, cats, reptiles)
- Wild animals
- Food
- Soil
- Water

Germs Get Around

(Mode of Transmission)

- Contact (hands, toys, sand)
- Droplets (when you speak, sneeze or cough)

How Germs Get Out

(Portal of Exit)

- Mouth (vomit, saliva)
- Cuts in the skin (blood)
- During diapering and toileting stool)

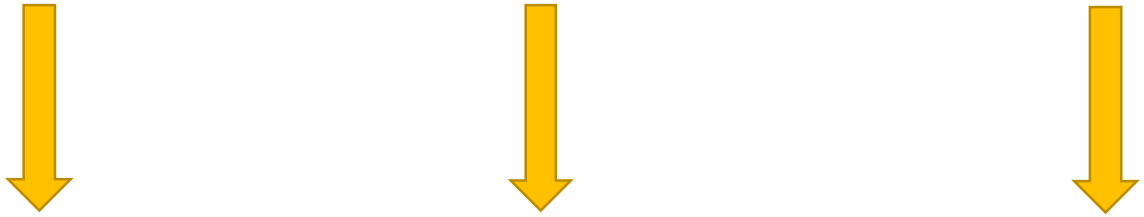
SOURCE & RESERVOIR

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

Animal reservoir

Non-living reservoir

Human reservoir

cases

- Primary case
- Secondary cases

According to spectrum of disease:

- Clinical cases (mild/severe-typical/atypical)
- Sub-clinical cases
- Latent infection cases

carriers

Type:
- Incubatory
- Convalescent
- healthy

Duration:
- ❖ Temporary
- Chronic

Portal of exit:
- Urinary
- Intestinal
- Respiratory
- blood

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.

index case

is the patient in an outbreak who is first noticed by the health authorities, and who makes them aware that an outbreak might be emerging.

Primary case

- **Refers to the first case of a communicable disease introduced into the population, refers to the person who first brings a disease into a group of people—a school class, community, or country.**

- **Secondary cases**
- Are those developing from contact with primary case.

Carrier

Infected person or animal that harbors a specific agent in the absence of apparent clinical disease, & serves as a potential source of infection for others

– Carriers are less infectious than cases but are more dangerous epidemiologically (WHY?)

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

Three elements must 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.**

Classification of carriers:

I. On the basis of Type:

- **Incubatory Carriers:** are those who can transmit the agent during the incubation period before clinical illness begins.

e.g. Measles, Mumps, Polio, Pertussis, Influenza, Diphtheria, Hepatitis-

- **Convalescent Carriers**: are those who have recovered from their illness but remain capable of transmitting to others. , e.g. Typhoid, Bacillary Dysentery, Amoebic Dysentery,

Cholera, Diphtheria & Pertussis.

(Clinical recovery does not coincide with bacteriological recovery)

Convalescent carriers pose threat to the unprotected household member for example Typhoid fever in which patients may excrete the bacilli for 6-8 weeks.

- **Healthy carriers:** **emerge from subclinical cases without suffering from obvious disease, e.g. Poliomyelitis, Cholera, Meningococcal Meningitis, Diphtheria &Salmonellosis**

II -On the basis of Duration of infection:

– **Temporary Carriers:** **shed infectious agent for short periods of time, e.g.**
Incubatory carriers, Convalescent carriers, Healthy carriers.

– **Chronic Carriers:** **are those who continue to harbor a pathogen such as hepatitis B virus or Salmonella Typhi, the causative agent of typhoid fever, for months or even years after their initial infection.**

One famous carrier is Mary Mallon, or Typhoid Mary, who was an asymptomatic chronic carrier of Salmonella Typhi. As a cook in New York City and New Jersey in the early 1900s, she unintentionally infected dozens of people until she was placed in isolation on an island in the East River, where she died 23 years later

III-On the basis of portal of exit:

Carriers are also classified according to the portal of exit to the infectious agents.

Therefore, there are urinary carrier, intestinal carriers, nasal carrier etc.

In typhoid fever, urinary carrier is more dangerous than an intestinal carrier.

Animal reservoirs

Humans are also subject to diseases that have animal reservoirs. Many of these diseases are transmitted from animal to animal, with humans as incidental hosts.

The term zoonosis refers to an infectious disease that is transmissible under natural conditions from vertebrate animals to humans.

There are over a 100 zoonotic diseases that can be carried from animal to man. e.g. rabies, plague, bovine tuberculosis.....

Many newly recognized infectious diseases in humans, including HIV/AIDS, Ebola infection and SARS, are thought to have emerged from animal hosts, although those hosts have not yet been identified.

Reservoir in non-living things(Environmental reservoirs)

- **Nonliving reservoirs of infection include water, food, and soil.**
  - **Water is the most dangerous.**
  - **Pathogens found in soil generally require the skin to be broken for entry into the body.**

Many of the agents are basically saprophytes living in soil and fully adapted to live freely in nature.
Biologically, they are usually equipped to withstand marked environmental changes in temperature and humidity.

- **Clostridium botulinum etiologic agent of Botulism.**
- **Clostridium tetani etiologic agent of Tetanus.**

- **Clostridium welchi etiologic agent of gas gangrene.**