



My reservoir is like the distance between Aden and Amman in al-Balqa

50

**Al-Balqa Applied University**



***Faculty of Medicine***

**Epidemiology and Biostatistics**

**الوبائيات والإحصاء الحيوي (31505204)**

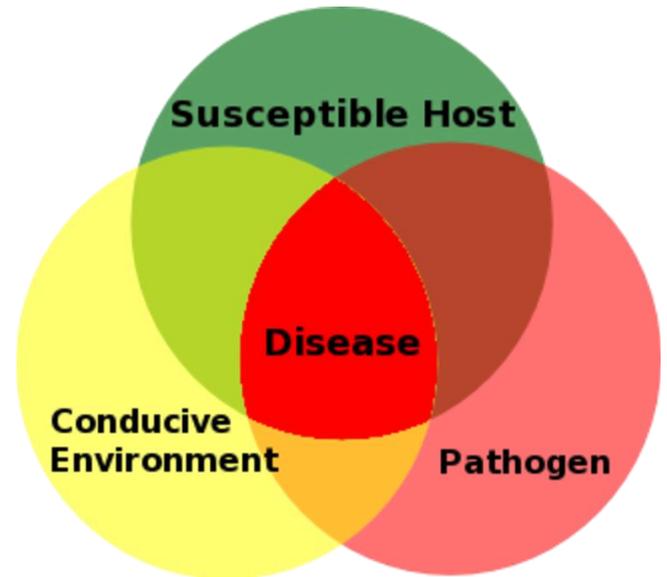
***Lecture 14***

**Basic epidemiological concepts/  
Epidemiological study types**

**21-7-2019**

# Epidemiology

- Epi = upon
- Demos = population
- Logos = study of



## □ *Definition*

- The study of the **distribution and determinants of health related states or events** in **specified human populations** and its **application to the control of health problems** (Last, 1988)

# Epidemiological Principles

- Diseases (or other health events) **don't occur at random.**
- Diseases (or other health events) have **causal and preventive factors** which can be identified.
- Diseases and health have a **distribution.**
- Epidemiology focuses on **populations rather than individual persons, tissues or organs.**
- « The art of epidemiological thinking is to draw **conclusions from imperfect data** » George W. Comstock

Comstock

# Major components of the definition

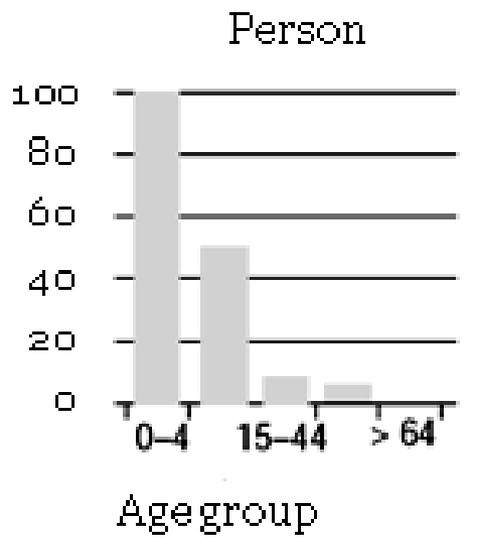
## 1. Population

- The main focus of epidemiology is on the effect of disease on the **population rather than individuals**.
- For **example malaria affects many people** in Ethiopia **but lung cancer is rare**. If an individual develops lung cancer, it is more likely that he/she will die.
- Even though lung cancer is more killer, epidemiology gives **more emphasis** to malaria since it affects many people.

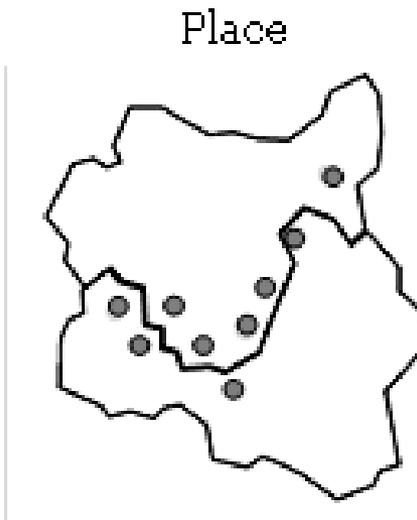
# Major components of the definition

- 2. Frequency.** This shows that **epidemiology is mainly a quantitative** science. Epidemiology is concerned with the frequency (occurrence) of diseases and other health related conditions. Frequency of diseases is measured by **morbidity and mortality rates**.
- 3. Health related conditions.** Epidemiology is concerned **not only with disease** but also with other health related conditions because every thing around us and what we do also affects our health. Health related conditions are conditions which **directly or indirectly** affect or influence health. These may be *injuries, births, health related behaviors like smoking, unemployment, poverty* etc.
- 4. Distribution.** Distribution refers to the **geographical distribution** of diseases, the distribution in **time**, and distribution by type of **persons** affected. (**Where, When and Who**).

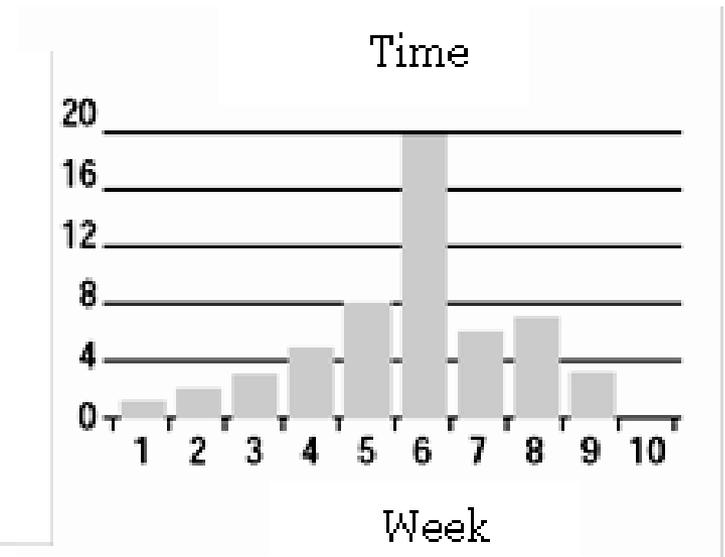
# Description of Disease Distribution in the Population



Disease affects mostly people under five years of age



Disease affects people living alongside the river



Disease reaches its peak in frequency in Week 6

# Major components of the definition

5. **Determinants.** Determinants are factors which determine whether or **not** a person will get a disease.
  
6. **Application of the studies to the promotion of health and to the prevention and control of health problems.**
  - **This means the whole aim in studying the frequency, distribution, and determinants of disease is to identify effective disease prevention and control strategies.**

# Basic Epidemiologic Approach

- **Observe**
  - **Count cases (events)**
  - **Describe**
    - Time, place, person
    - Calculate rates,
  - **Compare rates**
  - **Develop hypotheses**
  - **Test hypotheses**
  - **Implement actions (control, prevention)**
- Descriptive Epidemiology**
- Analytical Epidemiology**
- 
- The diagram uses yellow and cyan brackets to group the steps. A large yellow bracket on the right side groups the first five steps (Observe, Count cases, Describe, Compare rates, and Develop hypotheses) under the label 'Descriptive Epidemiology'. A smaller cyan bracket on the right side groups the last two steps (Test hypotheses and Implement actions) under the label 'Analytical Epidemiology'.

# Natural history of disease

- ❑ The “natural history of disease” refers to the **progression of disease process** in an individual over time, in the absence of intervention.
  
- ❑ There are **four stages** in the natural history of a disease. These are:
  1. Stage of **susceptibility**
  2. Stage of **pre-symptomatic (sub-clinical)** disease
  3. Stage of **clinical disease**
  4. Stage of **recovery, disability or death**

# **Aims of Epidemiology**

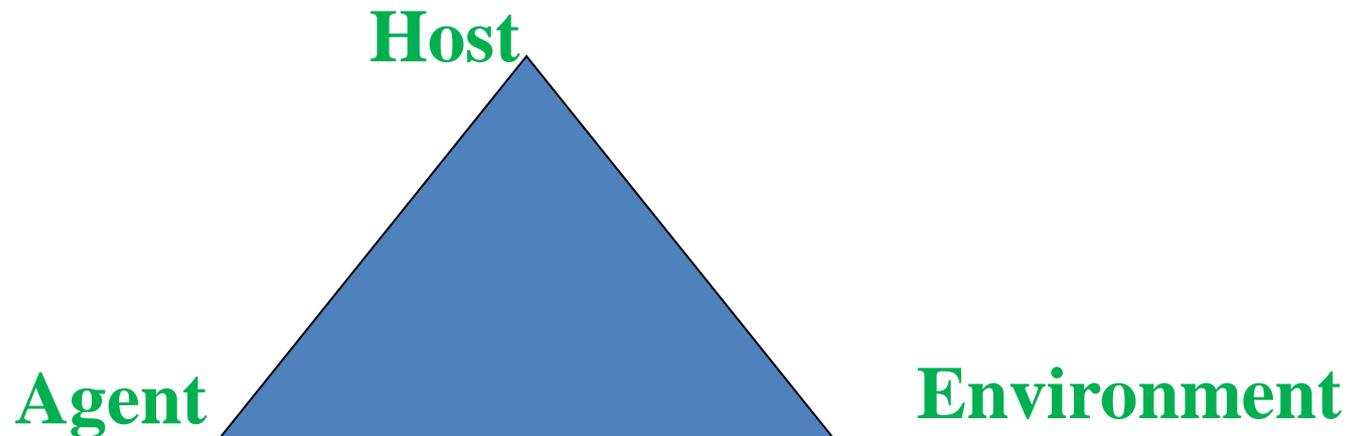
- 1. Describe the health status of population.**
- 2. Explain the etiology of disease.**
- 3. Predict the frequency and distribution of disease.**
- 4. Control diseases in populations**

# Uses of Epidemiology

- **Determine the magnitude and trends.**
- **Identify the etiology or cause of disease.**
- **Determine the mode of transmission.**
- **Identify risk factors or susceptibility.**
- **Determine the role of the environment.**
- **Evaluate the impact of the control measures.**

# Epidemiologic triad

- **Demographic characteristics**
- **Biological characteristics**
- **Socioeconomic characteristics**



- **Biological agents**
- **Physical agents**
- **Chemical agents**
- **Nutrient agents**
- **Mechanical agents**
- **Social agents**

- **Physical environment**
- **Biological environment**
- **Social environment**

# Host, Agent, Environment

Host	Agent	Environment
Age	Biologic	Disease vectors
Sex	Microorganisms	Population density
Religion	Chemical Toxins	Air quality
SES	Physical Trauma	Weather
Exercise	Nutrition	Noise
Behavior		Food and water sources
Co-morbidity		
Genetics		

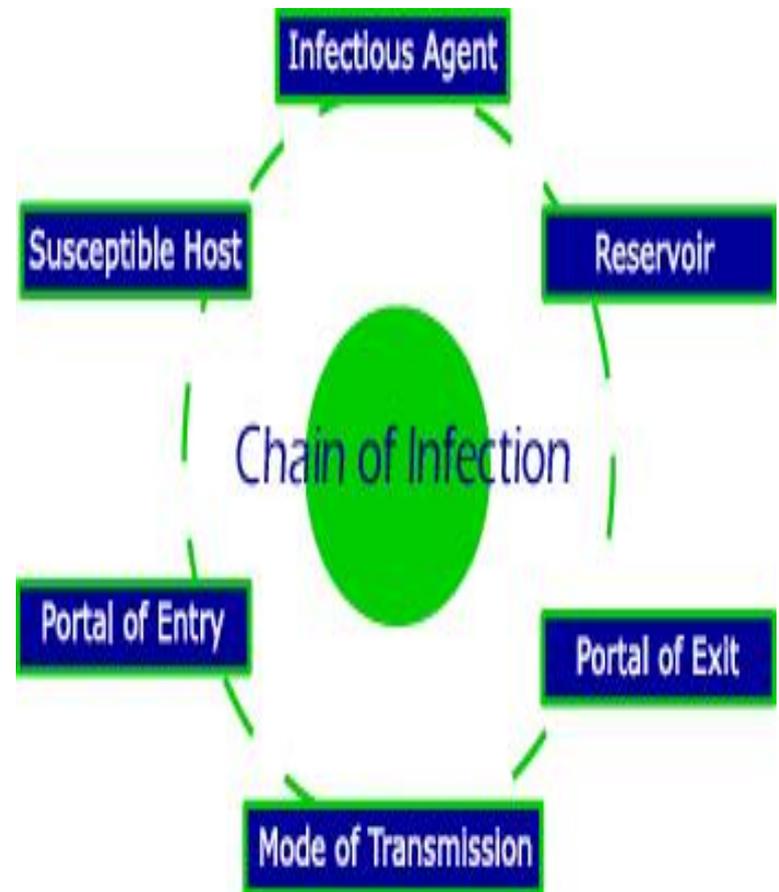
# Basic Epidemiological Terms

- **The Host**: is the organism that is susceptible to the effect of the agent. The status of the host is very important and is generally classifiable as: **susceptible**, **immune** or **infected**. The host's response can vary from showing no effect to manifesting subclinical disease, atypical symptoms, straight forward illness or severe illness.
- **The Environment** : is the conditions or influences that are **not part** of either the agent or the host, **but that influence their interaction**. A wide variety of factors including physical, climatologic, biologic, social and economic factors can come into play.

# Components of the infectious process

❑ The infectious process of a specific disease can be described by the following components, which constitute of the **chain of disease transmission**.

1. The Agent
2. Its reservoirs
3. Its portal of exits
4. Its mode of transmission
5. Its portals of entry
6. The human host



# Components of the infectious process

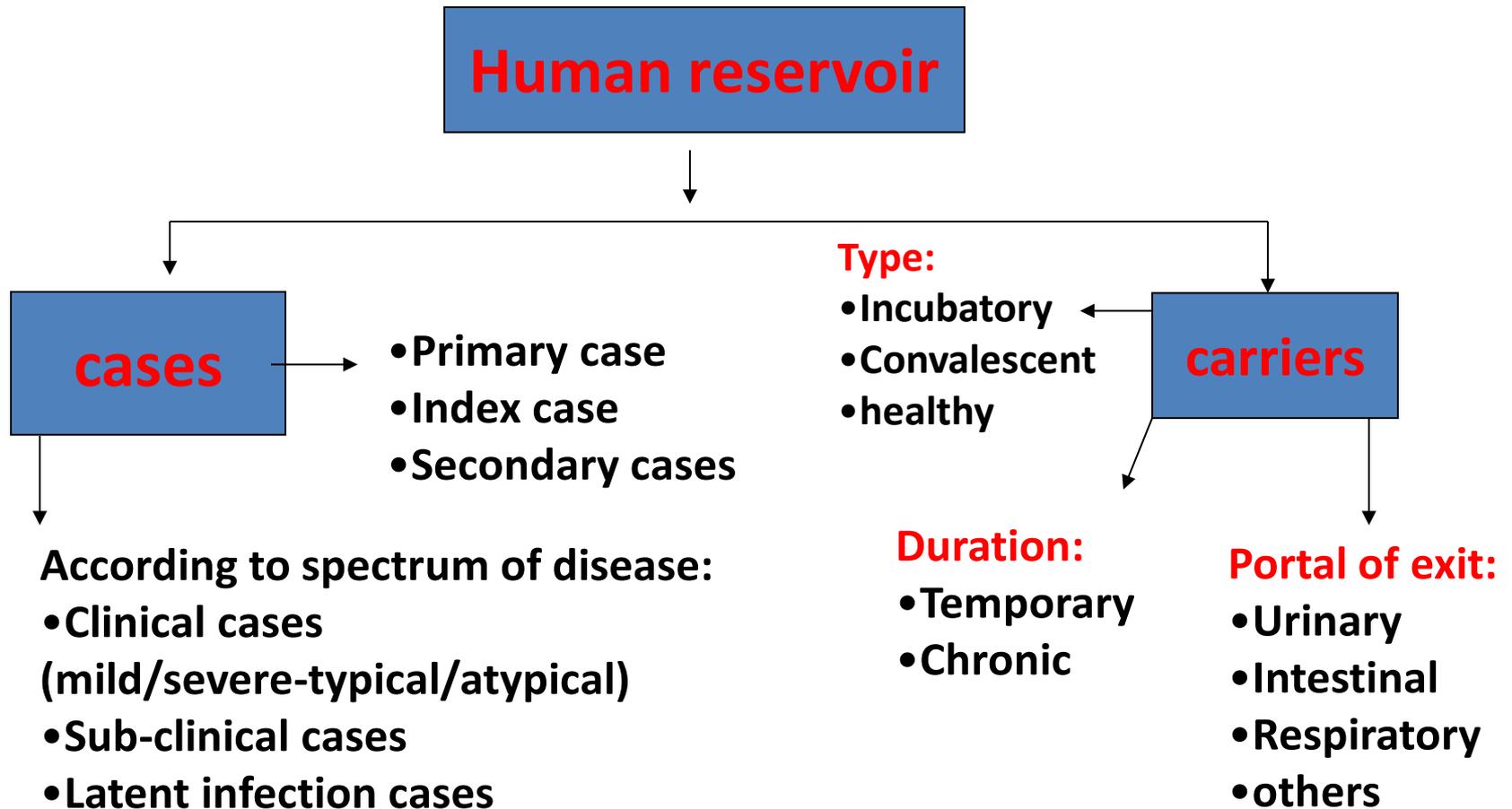
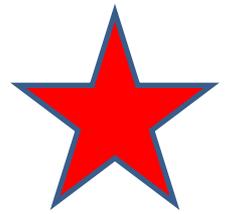
## □ I. The Agents

- The agents in the infectious process range from **viral particles to complex multi-cellular organisms.**

## □ II. Reservoirs

- A reservoir is an **organism or habitat, in which an infectious agent normally lives, transforms, develops and/or multiplies.**
- Reservoirs for infectious agents may be **humans, animals, plants or other inanimate objects.**

# Human reservoir



# Carriers

- ❑ A Carrier is defined as an **infected person or animal that harbors a specific infectious agent in the absence of discernible clinical disease and serves as a potential source of infection for others.**
- ❑ It occurs either due to **inadequate treatment or immune response, the disease agent is not completely eliminated, leading to a carrier state.**

# 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*”

# Components of the infectious process



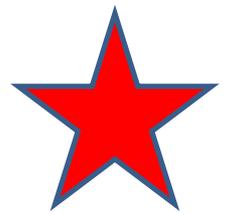
- Some diseases **with human reservoirs are**: Most bacterial and viral respiratory diseases HIV/AIDS/Sexually Transmitted Infections (STIs), **measles, typhoid etc.**
- All infected humans, **whether showing signs and symptoms** of the disease or not, **are potential sources of infection to others.**
- A person who does **not have apparent** clinical disease, but is a **potential source of infection to other people** is called a ***Carrier. An example of carrier is a person infected with HIV.*** A person infected with HIV might not have the signs and symptoms but he/she is capable of transmitting the infection to others.
- Some diseases are **transmitted to human beings from animals.** These diseases are called ***zoonoses.*** Examples: **Rabies, anthrax,** etc.

# Components of the infectious process

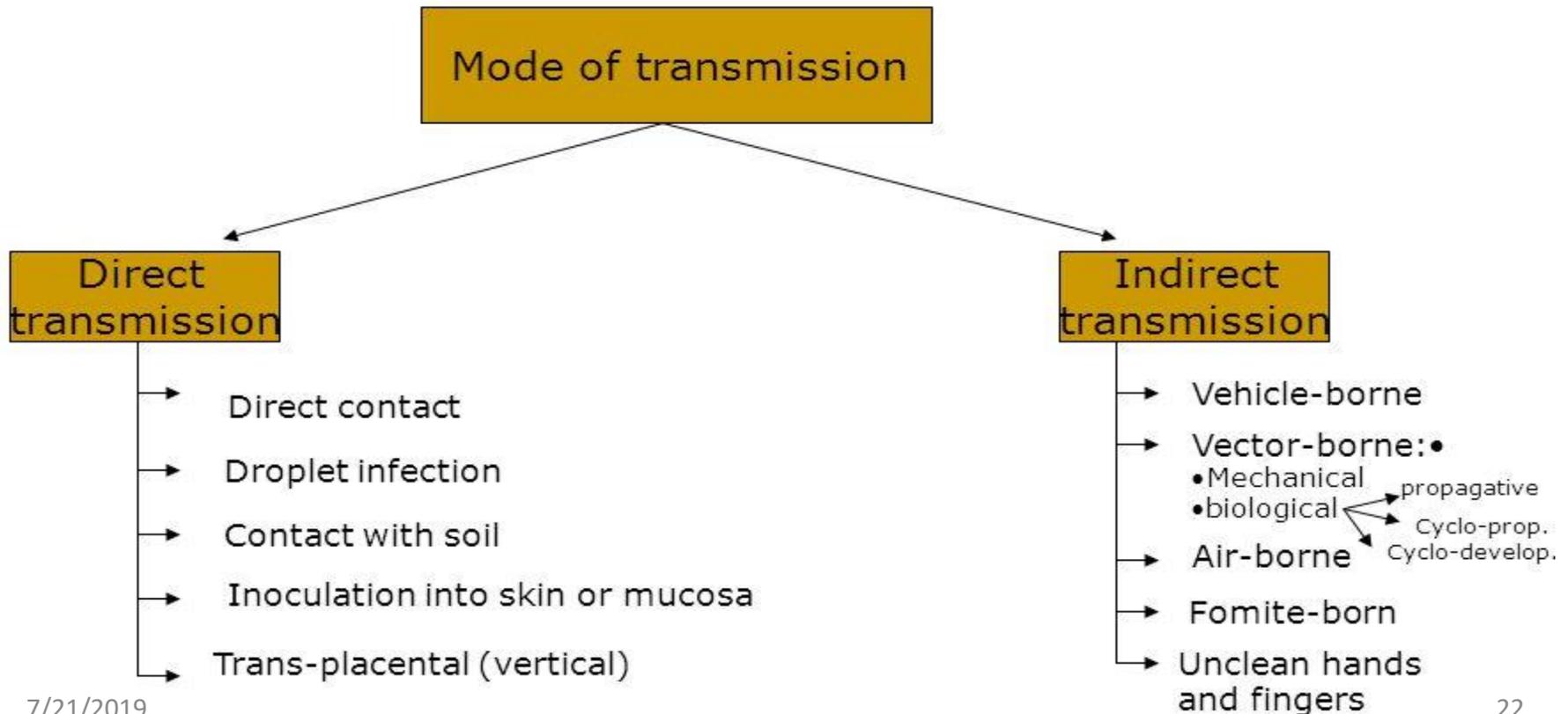
## □ III. Portal of Exit

- Portal of exit is the **way the infectious agent leaves the reservoir.**
- Possible portals of exit include all body secretions and discharges: **Mucus, saliva, tears, breast milk, vaginal and cervical discharges, excretions (feces and urine), blood, and tissues.**
- For example feces is the portal of exit for the eggs of hook worm.

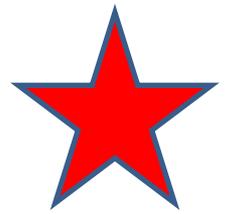
# □ IV. Mode of Transmission



- Modes of transmission **include the various mechanisms by which agents are conveyed to other susceptible hosts.**



# IV. Mode of Transmission

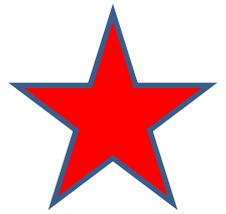


□ Transmission may be direct or indirect.

## 1. Direct Transmission

- **1.1 Direct contact**: Occurs when there is **contact of skin, mucosa, or conjunctiva** with infectious agents directly from person or vertebrate animal, **via touching, kissing, biting, passage through the birth canal, or during sexual intercourse.** Example: **HIV/AIDS/STIs, rabies.**
- **1.2 Direct Projection**: is transmission by projection of **saliva droplets** during coughing, sneezing, singing, spitting or talking. Example: **common cold.**
- **1.3 Transplacental**: is transmission from mother to fetus **through** the placenta. Example: syphilis, HIV/AIDS

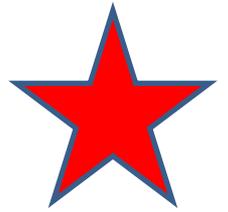
# Indirect transmission



**2. Indirect transmission** The following are the different types of indirect transmission.

- **2.1 Vehicle-borne:** *Transmission occurs through indirect* contact with **inanimate objects** fomites: **bed sheets, towels, toys**, or surgical instruments; as well as through contaminated food, water, IV fluids etc.
- **2.2 Vector-borne:** *The infectious agent is conveyed by an arthropod to a host.* Vectors may be **biological or mechanical**.
  - **Biological vector:** *A vector is called biological vector if the agent multiplies* in the vector before transmission. • Example: **anopheles mosquito is a biological vector for malaria.**
  - **Mechanical vector:** *A vector is called mechanical vector if the agent is directly infective to other hosts, without* having to go through a period of **multiplication** or development in the vector. The vector simply carries the agent by its body parts( leg, proboscis etc) to convey it to susceptible hosts. Example: **Flies are mechanical vectors for the transmission of trachoma.**

# Indirect transmission



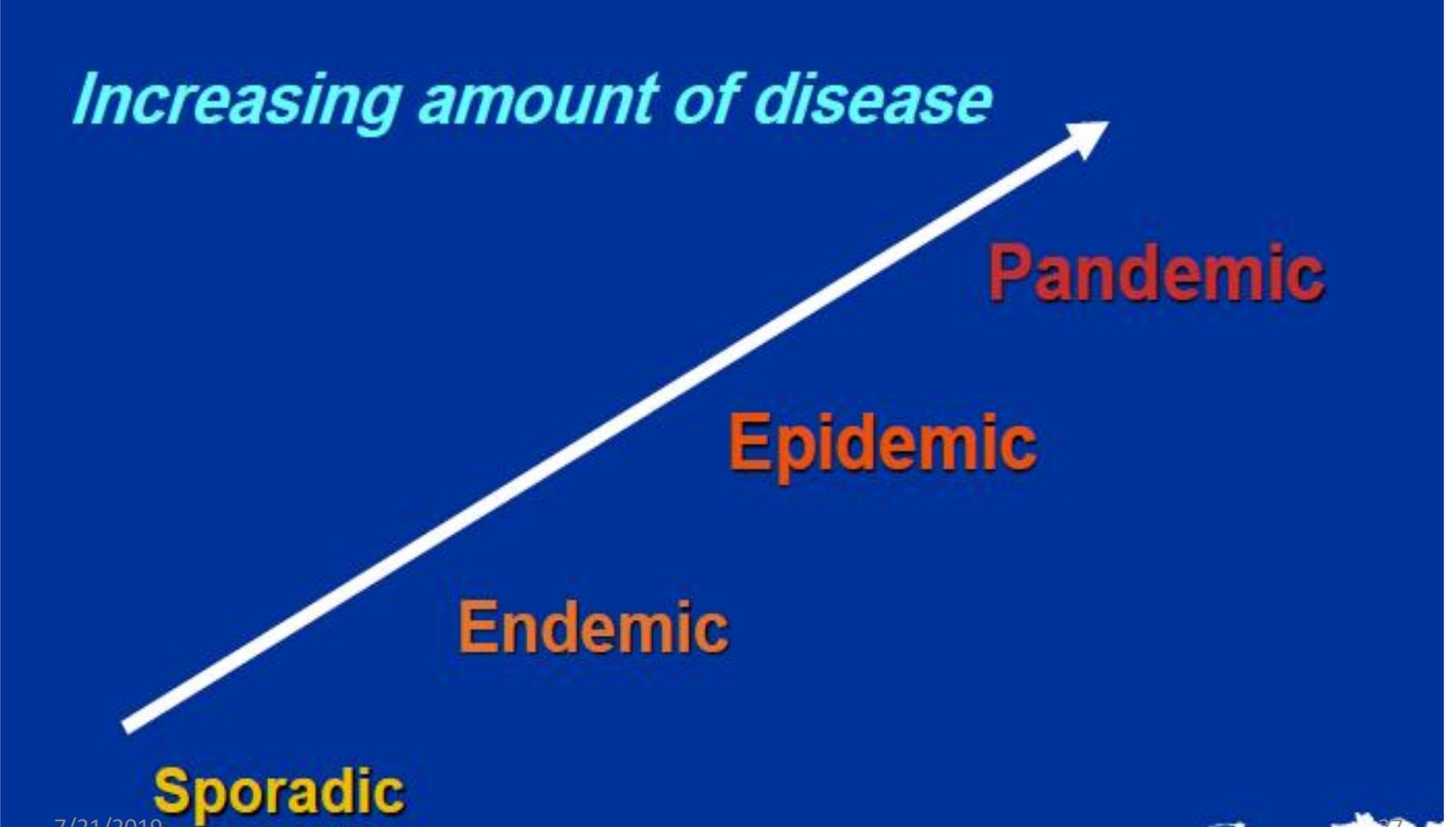
- **2.3 Airborne:** *which may occur **by dust or droplet nuclei** (dried residue of aerosols).*
- **Example: Tuberculosis.** When pulmonary tuberculosis patients cough, they emit many **aerosols** which consists the agents of tuberculosis. When these aerosols dry droplet nuclei will be formed. These droplet nuclei will remain suspended in the air for some time. When another **healthy susceptible** individual breaths he/she will inhale the droplet nuclei and become infected with tuberculosis.

# Basic Epidemiological Terms

- **Disease Incidence (*rate*):** Number of **new cases** within a certain time period divided by the total number of **susceptible individuals** in the population.
- **Disease Prevalence (*proportion*):** Number of total **existing cases** divided by the total of population.

# Levels of disease

*Increasing amount of disease*



The diagram features a white arrow pointing from the bottom-left to the top-right. The arrow is labeled with the text 'Increasing amount of disease' in a light blue, italicized font. Along the path of the arrow, four levels of disease are listed in a diagonal sequence: Sporadic (yellow text), Endemic (orange text), Epidemic (orange text), and Pandemic (red text). The background is a solid dark blue.

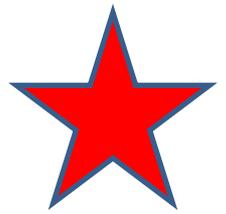
**Pandemic**

**Epidemic**

**Endemic**

**Sporadic**

# Sporadic



- The word sporadic means “**scattered about**”. The **cases occur irregularly, haphazardly from time to time, and generally infrequently.**
- The cases are few and separated widely in time and place that they show no , or little connection with each other, **nor** a recognizable common source of infection e.g. **polio, meningococcal meningitis, tetanus....**
- However, a sporadic disease **could be the starting point of an epidemic** when the conditions are favorable for its spread.

# Endemic

- ❑ It refers to the constant presence of a disease or infectious agent within a given geographic area or population group. It is **the usual or expected frequency of disease** within a population (constantly present in population).
- ❑ **Example:** Malaria is a constant worry in parts of Africa , ear infection ..

# Hyperendemic and Holoendemic

- The term “**Hyperendemic**” expresses that the disease is **constantly present at high incidence and/or prevalence rate and affects all age groups equally.**
- The term “**Holoendemic**” expresses a **high level of infection** beginning **early in life and affecting most of the child population**, leading to a state of equilibrium such that the **adult population shows evidence of the disease much less commonly than do the children (e.g. malaria).**

# Epidemic

- “The **unusual occurrence in a community of disease**, specific health related behavior, or other health related events clearly **in excess of expected occurrence**”.
- An **outbreak of disease** that attacks many peoples at about the same time and may spread through one or several communities.

# Pandemic and Exotic

- **An epidemic** usually affecting *a large proportion of the population*, occurring over a **wide geographic** area such as a section of a nation, the entire nation, a continent or the world, **e.g. Influenza pandemics**.
- **Exotic diseases** are those which **are imported** into a country in which they **do not otherwise** occur, as for example, rabies in the UK.

# Zoonosis, epizootic and enzootic

- Zoonosis is an infection that is transmissible under natural conditions from vertebrate animals to man, e.g. rabies, plague, bovine tuberculosis..
- An epizotic is an *outbreak (epidemic) of disease in an animal population, e.g. rift valley fever.*
- An Enzotic is an endemic occurring in animals, e.g. bovine TB.

# Nosocomial infections

- **Nosocomial** (*hospital acquired*) infection is an infection originating in a patient while in a hospital or another health care facility.
- It has to be a new **disorder unrelated to the patient's primary condition.**
- **Examples** include infection of **surgical wounds**, **hepatitis B** and **urinary tract infections.**

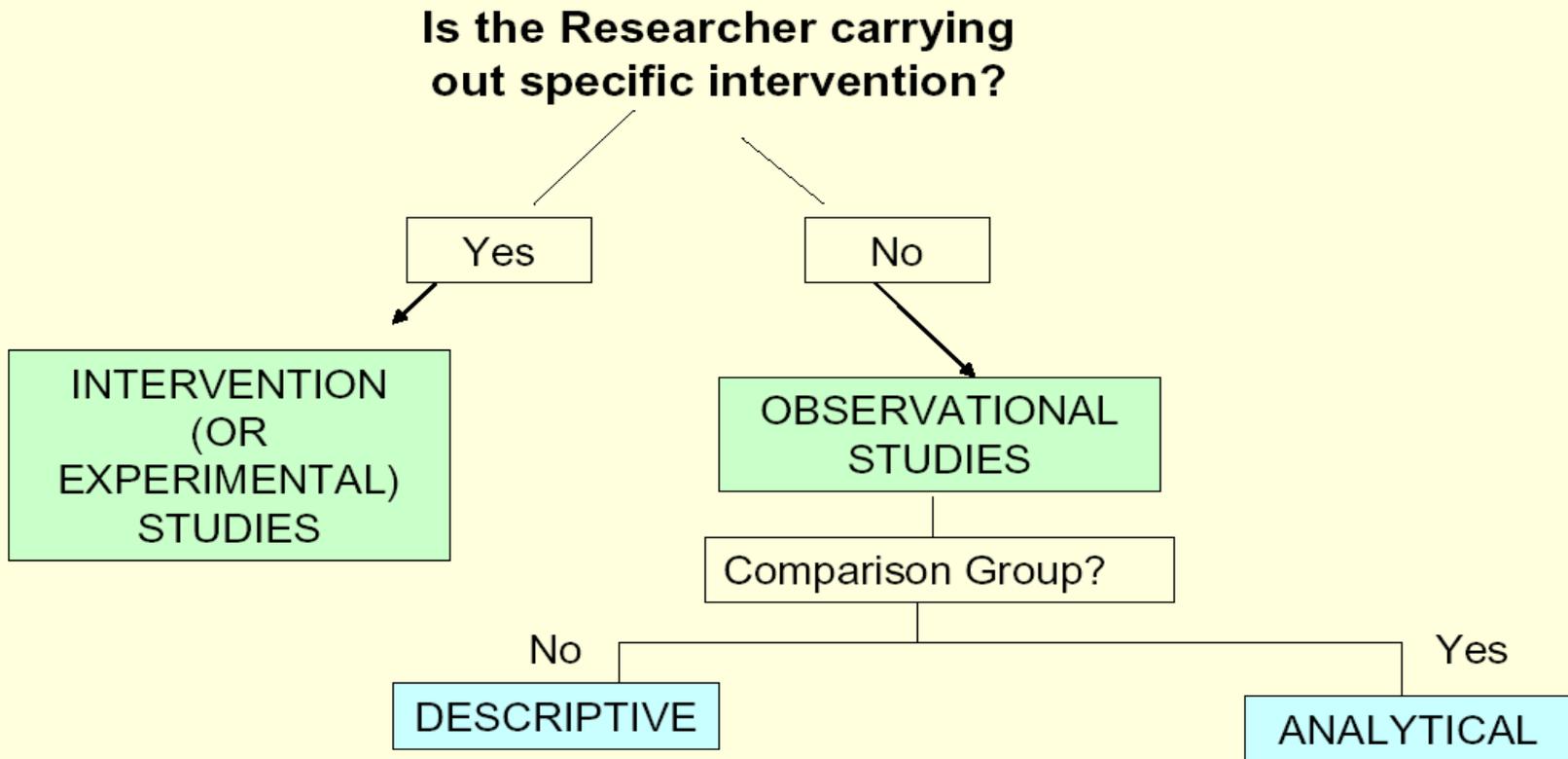
# Basic Epidemiological Terms

- **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.
- **Infectious (communicable) period:** *length of time a person can transmit disease.*
- **Virulence:** **The severity of disease that the agent causes to the host.**

# Classification



## Epidemiologic Study Designs



# Aims of Epidemiologic Research

1. Describe the health status of a population
  2. To assess the public health importance of diseases
  3. To describe the natural history of disease,
  4. Explain the etiology of disease
  5. Predict the disease occurrence
  6. To evaluate the prevention and control of disease
  7. Control the disease distribution
- 
- The diagram uses brackets and an arrow to group the aims of epidemiologic research into three categories:
- Descriptive epidemiology** (Aims 1-3)
  - Analytic epidemiology** (Aims 4-6)
  - Applied epidemiology** (Aim 7)

# Basic Questions in Analytic Epidemiology

- **Look to link exposure and disease**
  - What is the exposure?
  - Who are the exposed?
  - What are the potential health effects?
  - What approach will you take to study the relationship between exposure and effect?

# Descriptive and Analytical Epidemiology

## 1. Descriptive epidemiology

- Describes the occurrence of disease.

## 2. Analytic epidemiology:

- **Observational** (cohort, case control, cross-sectional, ecologic study) – researcher observes association between exposure and disease, estimates and tests it.
- **Experimental** (RCT, quasi experiment) – researcher assigns intervention (treatment), and estimates and tests its effect on health outcome.

# Observational Vs Experimental Studies

## □ Observational studies

- **Allow nature to take its course; the investigator measures but does not intervene.**
- **Descriptive study:** focuses on the **description of the occurrence** of a disease in a population.
- **Analytical study** analyses **relationships between** health status and other variables.

# Observational VS Experimental Studies

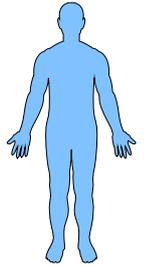
- **Experimental or interventional** studies: **involve an active attempt to change a disease** determinant(e.g an exposure or a behaviour) or the progress of a disease (through treatment).
- You **do something to the world** and see what happens.
- You gather data or information almost always **before and after** the intervention, then look for **changes**.

# Observational studies

# Cross-sectional Study

- **Cross-sectional:** Is a research tool used to capture information based on data gathered for a **specific point in time (Prevalence)**. *Prevalence or relation between two things.*
  - It is also called epidemiologic study or **prevalence study**.
  - It analyses (describes) data collected on a group of subjects at **one point in time rather than over a period** of time. i.e they survey exposure and disease at a single point in time.
  - Both **exposure and outcome** variables are been evaluated at the **same point in time**.
  - It answers the question “**WHAT IS HAPPENING RIGHT NOW?**”

# Cross-sectional studies



## ❑ Advantages

- Fast , relatively easy and inexpensive to conduct.
- Useful to investigating exposures that are fixed characteristics of individuals such as blood group or ethnicity....
- No loss to follow up.
- Data from cross sectional studies are helpful in assessing the health care needs of population.

## ❑ Disadvantages

- **Weakest observational design**, (it measures prevalence, **not** incidence of disease).
- **Response rate may be low ,with result not representative of the population.**
- The **temporal sequence** of exposure and effect may be difficult or impossible to determine.
- **Usually don't know when disease occurred.**
- Can't determine causal relationship.
- Impractical for rare diseases.

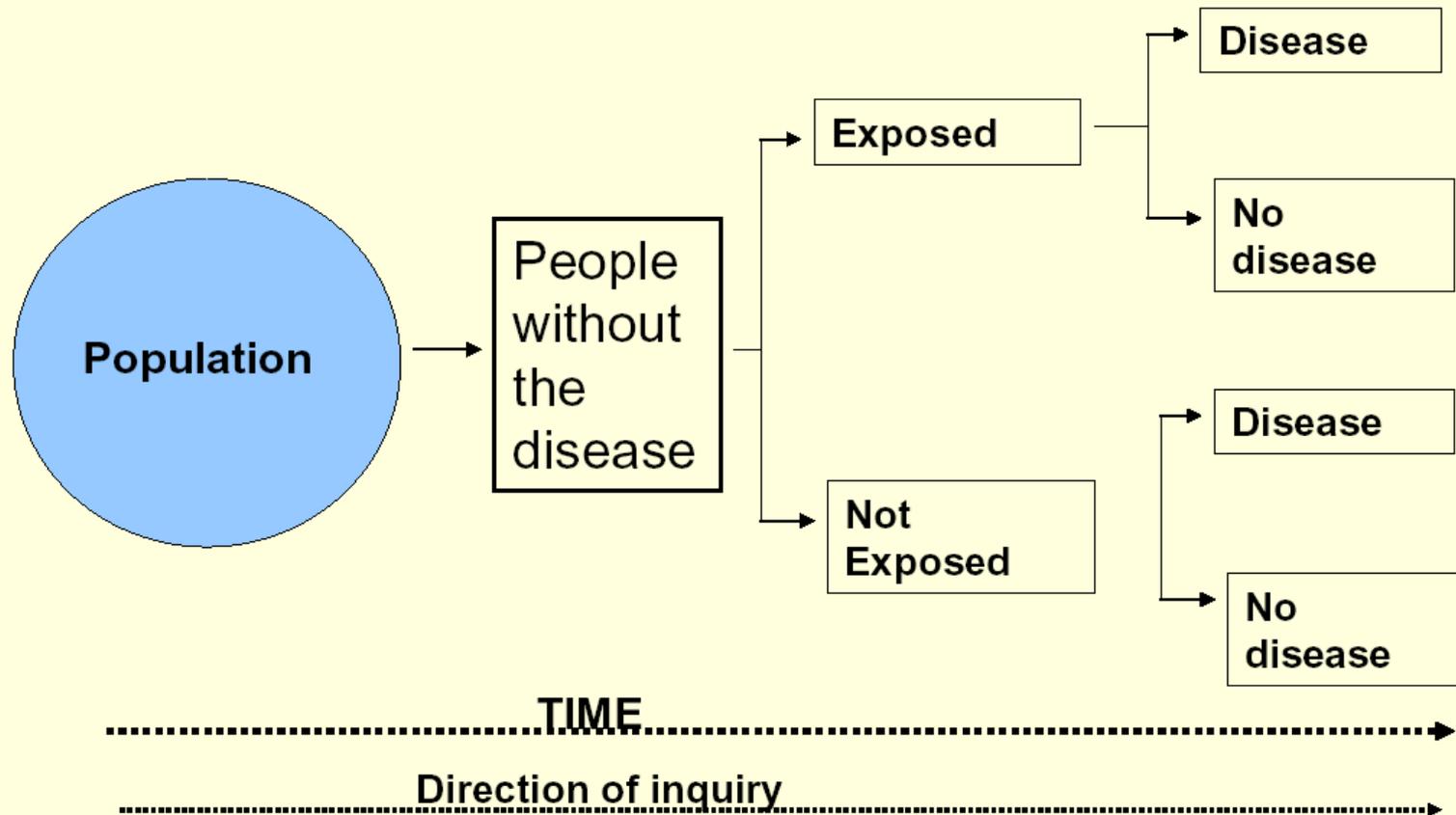
# Cohort study (longitudinal study)

- **Cohort studies** are a type of medical research used to investigate the **causes of disease** and to establish **links between risk factors and health outcomes**.
  
- 1. **Prospective studies** are planned in advance and carried out over a future period of time.
- 2. **Retrospective cohort studies ( Historical)** look at data that already exist and try to identify risk factors for particular conditions.
  
- Cohort studies typically observe **large groups of individuals**, recording their exposure to certain risk factors to find clues as to the possible causes of disease.

# Cohort Study

- A cohort is a **group of people who have something in common and remain part of a group over an extended time.**
- A group of people **exposed** to a suspected etiological agent are compared with a matched control who have not been similarly exposed. Subject selected on the basis of exposure [etiological factor; cigarette smoking].
- *Follow-up over a period to compare the outcome*

# Classical Design of a Cohort Study



# Advantages of Cohort

- There is **no bias**.
- The risk can be calculated -the incidence can be calculated.
- It is **effective** for studying **rare exposures**.
- It allows the study of **the natural history of the disease**.
- It assists in determining the **temporal relationship** between the etiological factor & the disease.

# Disadv of cohort study

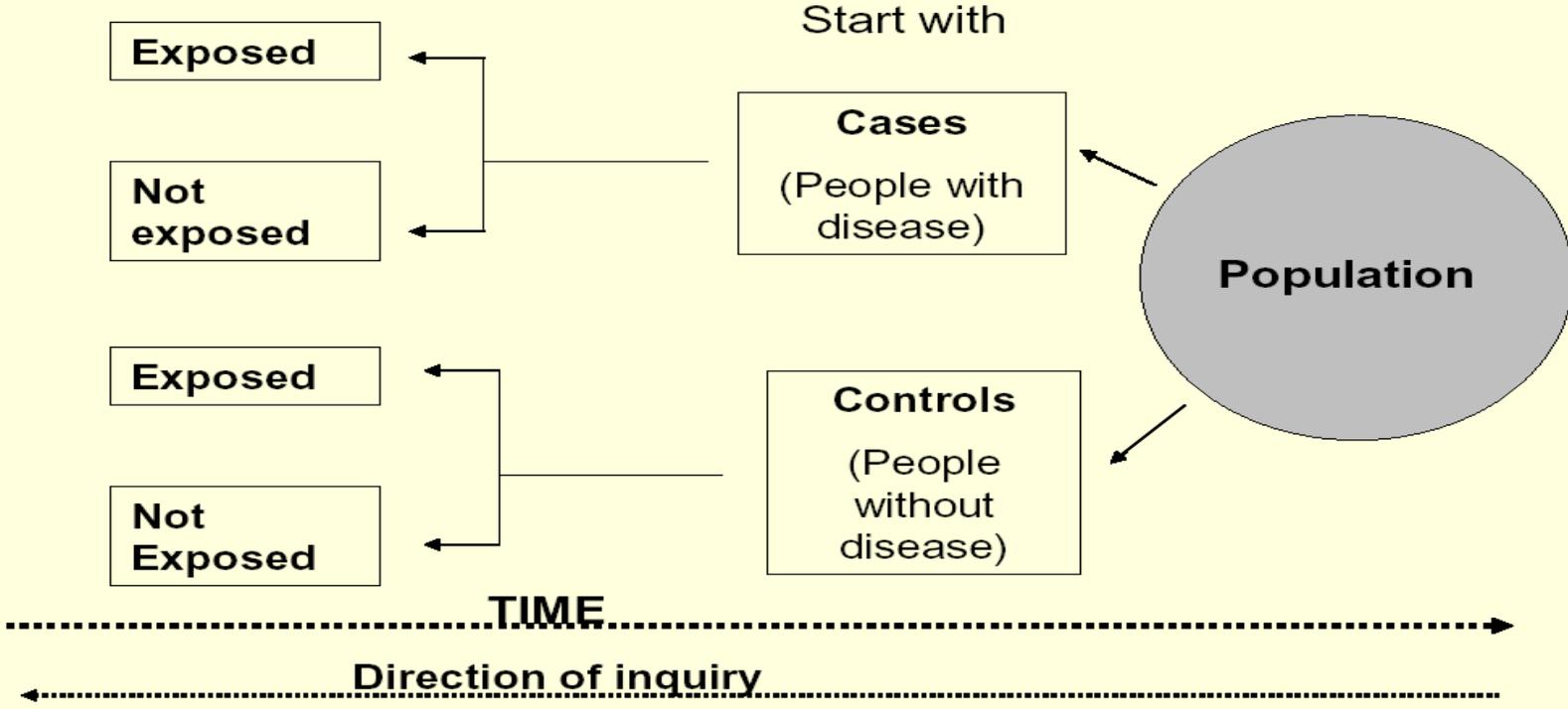
- It takes a long time.
- It is expensive
- **Large number** of subjects are needed.
- There **could be changes** in the standard methods or diagnostic criteria.

# Case Control **or** Case History Study

- **A group of affected people is compared to unaffected people (the control).**
- It's a **LONGITUDNAL STUDY** (like cohort study) because it's a study over a period of time.
- Subjects are selected based on a particular **outcome** and a study **backwards** in time **to try** to detect the **causes or risk factors** that may have earlier been reported in a descriptive study.
- Subjects are then matched and assigned into the two groups. Subject selected on the basis of disease[e.g lung cancer].
- **Sometimes called a retrospective study because of the direction of study.**

# Case Control or Case History Study

## Design of a Case-Control Study



# Advantages of case control

- It is relatively **easy to carry** out because we go back to existing records in the hospital.
- It is also **rapid and inexpensive**.
- Good for **rare diseases**.
- It requires **comparatively few subjects**.
- One does **not** need an **ethical clearance**.

# Disadvantages of case control

- It introduces **bias**.
- *To select an appropriate control could be difficult.*
- It may be difficult to **distinguish between the cause of a disease and an associated factor.**

# Analytical Studies

## Two basic designs:

- **Case – control or retrospective study.**
- **Cohort or prospective.**

## NOTE

- **There must be a comparison group.**
- **No control No conclusion(NCNC).**

# Ecological Correlational Study Design

- A study ***comparing*** incidence/prevalence of one event against another on a global scale.
- **Measures** that represent characteristics of **entire populations are used to describe the** disease in relation to some factor of interest (such as age, calendar time, food consumption, drug use and utilization of health services).

# Ecological Correlational Study Design

## ADV

- **Compares events among nations.**

## DISADV

- **Doesn't compare individuals, so it might lead to overgeneralization.**

# Case Series

- **Case series:** collection of individual case reports which may occur within a **fairly short** time, and experience of a group of patients with **similar diagnosis.**

# Case Series

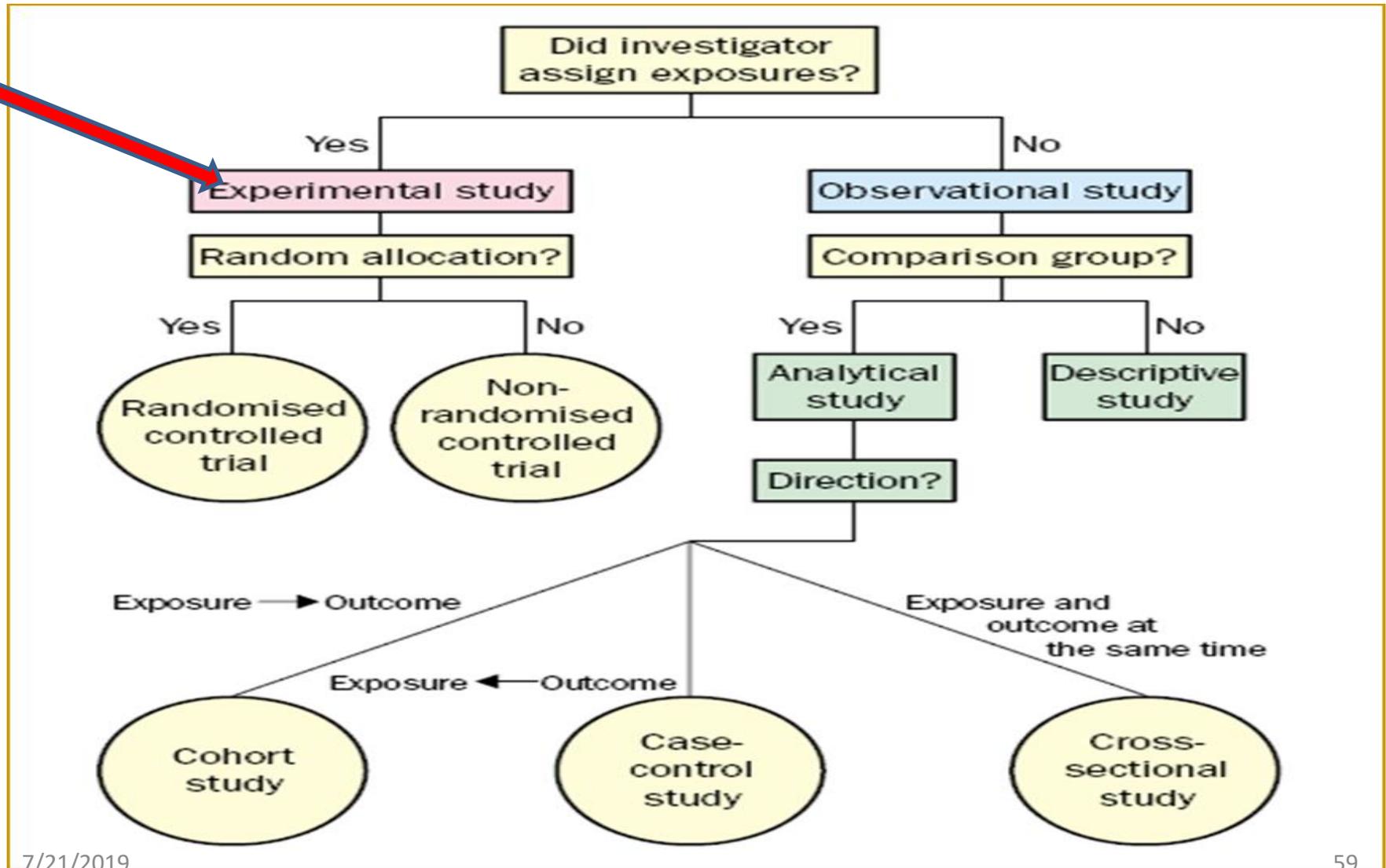
- **Advantages**

- Useful for hypothesis generation.
- Informative for very rare disease with few established risk factors.
- Usually of short duration.

- **Disadvantages**

- Cannot study cause and effect relationships.
- Cannot assess disease frequency.

# Epidemiologic Study Designs



# Experimental Studies

- The gold standard in medicine -it proves causality.
  - You can establish **causality**: X really does affect Y.
  - **Can be controlled or uncontrolled.**
- 
- **Uncontrolled** : Intervention is **not compared with a control**. The aim is to **confirm that the intervention made a difference**.
  - **Example**: Measure performance in 10 athletes before and after a training intervention.

# Controlled Experimental Studies

- In this study, a **drug or procedure is compared** to:
  - 1. Another drug**
  - 2. Procedure**
  - 3. Placebo**
- **Example:** Measure performance of 20 athletes before and after a drug and another 20 before and after a placebo.

# Experimental Studies

## ADV

1. **Best study type.**
2. **Greatest prove of causality.**
3. **Least bias.**
4. **Proves best treatment or procedure efficacy.**

## DISADV

1. **Greatest expense.**
2. **Long duration.**

# Experimental Studies

- In an experiment, we are interested in the consequences of some treatment on some outcome.
- The subjects in the study who actually receive the **treatment** of interest are called the **treatment group**.
- The subjects in the study who receive **no treatment** or a different treatment are called the **comparison group**.



# Epidemiologic Study Designs

## □ Randomized Controlled Trials (RCTs)

- A design with subjects **randomly assigned** to “treatment” and “comparison” groups.
- Provides **most convincing evidence of relationship between exposure and effect.**

# Randomized Controlled Trials

- **Disadvantages**

- **Very expensive**

- **Not appropriate to answer certain types of questions.**

- **It may be unethical, for example, to assign persons to certain treatment or comparison groups.**

# Study Design and Its Strength of Evidence

1. **Systematic review, meta-analysis:  
secondary data analysis**
2. **Randomized Controlled Trials (RCT)**
3. **Cohort: prospective or retrospective  
Quasi experiment**
4. **Case control: prospective or  
retrospective**
5. **Cross sectional**
6. **Case Reports / Case Series**

**Strongest  
evidence**



**Weakest  
evidence**