Principles of Epidemiology

Dr. Latefa Dardas

1

Epidemiology - Definition

- epi – means "on, upon, befall"
- demo – means "people, population, man"
- ology – means study of

❖Literally, epidemiology means: the science which deals with what falls upon people.

2

Epidemiology - Definition

- In epidemiology, the patient is the community and individuals are viewed collectively. By definition, epidemiology is **the study** (scientific, systematic, and data-driven) **of the distribution** (frequency, pattern) and determinants (causes, risk factors) **of health-related states and events** (not just diseases) in specified populations (neighborhood, school, city, state, country, global).

3

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Epidemiology - Definition

- An investigative method used to detect the **cause or source of diseases**, disorders, syndromes, conditions, or perils that cause pain, injury illness, disability, or death in human populations or groups.
- Study of the occurrence and **distribution of health-related diseases or events** in specified populations, including the study of the determinants influencing such states, and the application of this knowledge to control the health problem.
- Also involves **characterizing the distribution of heath status**, diseases, or other health problems in terms of age, sex, race, geography, religion, education, occupation, behaviors, time, place, person, etc.

4

Epidemiology - Definition

- Serves as **the foundation and logic of interventions** made in the interest of public health and preventive medicine.
- It is considered a cornerstone methodology of public health research, and is highly regarded in evidence-based medicine for identifying risk factors for disease and determining optimal treatment approaches to clinical practice.

5

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Epidemiology - Definition

- In the work of communicable and non-communicable diseases, the work of epidemiologists range from outbreak investigation to study design, data collection and analysis including the development of statistical models to test hypotheses and the documentation of results for submission to peer-reviewed journals.
- Epidemiologists may draw on a number of other scientific disciplines such as biology in understanding disease processes and social science disciplines including sociology and philosophy in order to better understand proximate and distal risk factors

6

Purposes of Epidemiology

- To explain the etiology (cause) of a single disease or group of diseases using information management.
- To study the history and trends of a disease.
- To determine if data are consistent with proposed hypothesis.
- To provide a basis for developing control measures and prevention procedures for groups and at risk populations.

7

Who are epidemiologists?

When disease outbreaks or other threats emerge, epidemiologists are on the scene to investigate. Often called "Disease Detectives", epidemiologists search for the cause of disease, identify people who are at risk, determine how to control or stop the spread or prevent it from happening again. Physicians, veterinarians, scientists, and other health professionals often train to be "Disease Detectives".

What do epidemiologists do?

Like investigators at the scene of a crime, disease detectives begin by looking for clues. They systematically gather information, asking questions such as:

- Who is sick?
- What are their symptoms?
- When did they get sick?
- Where could they have been exposed?

8

What public health problems or events are investigated?

Environmental exposures	• Lead and heavy metals • Air pollutants and other asthma triggers
Infectious diseases	• Foodborne illness • Influenza and pneumonia
Injuries	• Increased homicides in a community • National surge in domestic violence
Non-infectious diseases	• Localized or widespread rise in a particular type of cancer • Increase in a major birth defect
Natural disasters	• Hurricanes Katrina and Rita (2005) • Haiti earthquake (2010)
Terrorism	• World Trade Center (2001) • Anthrax release (2001)

9

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❖**Examples of the types of community health problems investigated by epidemiologists:**

- A measles outbreak on a small college campus
- A global influenza pandemic
- An increase in homicide in a community
- A national surge in violence
- An increase in the number of cancer cases

❖**Epidemiologists answer questions, such as:**

- Who is sick?
- What are their symptoms?
- When did they get sick?
- Where were they exposed to the illness?

10

Broad Types of Epidemiology

11

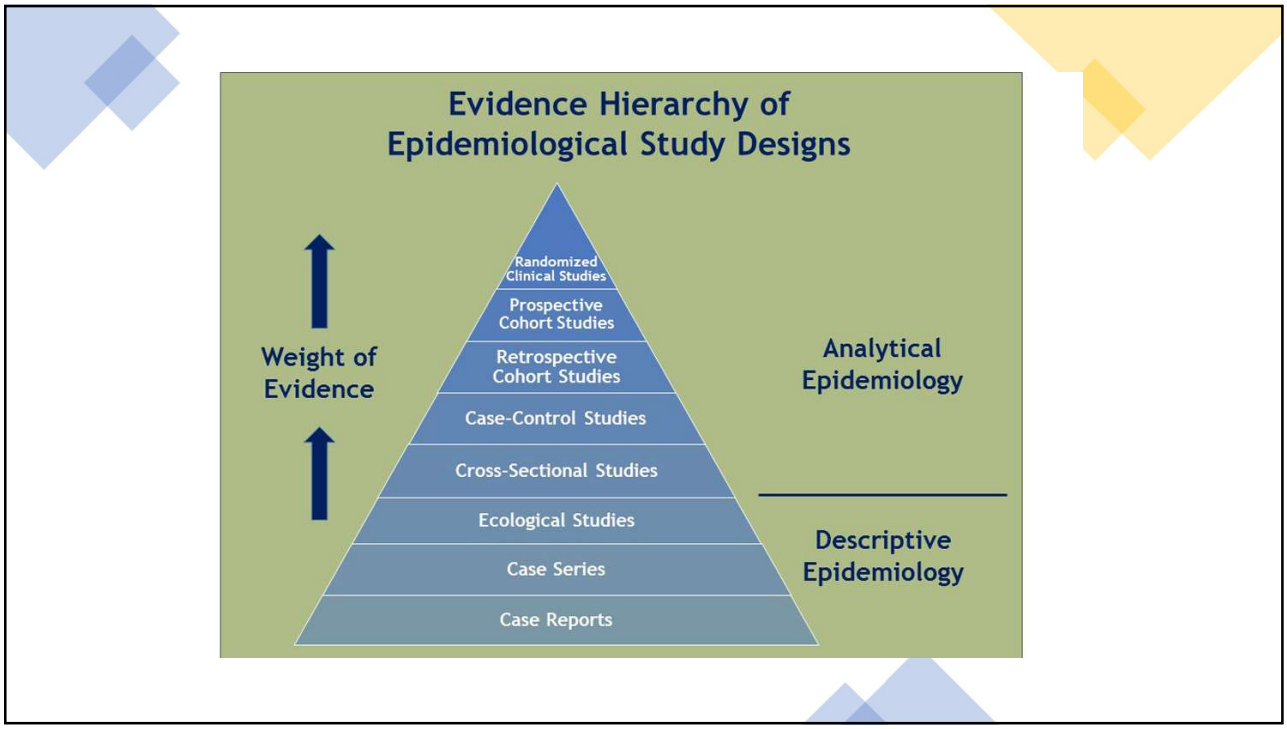
DESCRIPTIVE EPI

- Describes what exists in a population by person, place, or time variables.
- Descriptive studies are useful in demonstrating trends and generating hypotheses about disease causation.
- The epidemiologist collects information to characterize and summarize the health event or problem.

ANALYTIC EPI

- Makes inferences based on the data they collect. These inferences are the bases for hypotheses, which must be tested using one of two analytical study designs.
- Epidemiologists rely on comparisons between groups to determine what role various risk factors had in causing the problem.
- Two Types of Analytical Study Designs: 1. Cohort study design 2. Case-control study design

12



13

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Factors Impacting Epidemiology Studies

- Because epidemiology studies can only be conducted after people have been exposed to a chemical, they are not as useful as experimental studies for predicting and preventing adverse health effects.
- Epidemiology studies tend to produce less reliable data that can be more difficult to interpret. For instance, it is extremely rare that an epidemiology study alone can confirm that a particular chemical exposure caused a health effect. In fact, several published epidemiology studies are later proven to be wrong.

14

Factors Impacting Epidemiology Studies

- As it is considered unethical to randomly allocate humans into exposed and unexposed groups, epidemiologists can only observe, not control, the conditions under which people are exposed. Consequently, a vast, unknown number of other variables, referred to as confounders, may cloud our understanding of the relationship between a chemical exposure and observed health effects.
- Errors in measurements of exposure and disease also can occur, which can further skew findings. Potential confounding and measurement errors are especially problematic in studies that include a relatively small number of subjects (i.e., less than tens of thousands).

15

Basics of Descriptive Epidemiology

The three essential characteristics of disease we look for in descriptive epidemiology are:

- **PERSON**
- **PLACE**
- **TIME**

16

Personal Characteristics (whom)

- Age
- Gender
- Socio-economic status (education, occupation, income)
- Marital status
- Ethnicity/race/genetic profile
- Behavior / habits

17

Place (where ?)

- Geographically restricted or widespread.
- Climate effects (temperature, humidity, combined effects..)
- Urban / sub-urban-squatter / rural
- Relation to environmental exposure (water, food supply, etc)

18

Time (when ?)

- Changing or stable?
- Clustered (epidemic) or evenly distributed (endemic)
- Time-trends: Point source, propagated, seasonal, combinations

19

How epidemiology is applied in the core processes of public health practice

Four core processes are used in the field of epidemiology:

1. Surveillance
2. Screening
3. Outbreak investigation
4. Assessing causation

20

Surveillance

- The regular collection, meaningful analysis, and routine distribution of relevant data that provides opportunities for public health action to prevent and control disease.
- Reasons for surveillance: • Identify cases of diseases that pose immediate risk to communities • Detect clusters • Monitor trends of disease that may represent outbreaks • Evaluate control and prevention measures • Develop hypotheses for emerging diseases.
- Two categories of surveillance: *Active surveillance*: Consists of actively searching for cases by proactively calling and visiting hospitals. This type of surveillance is often conducted when an outbreak is detected. *Passive surveillance*: Refers to information provided to the health agency without an initiating action by the agency. This type of surveillance includes traditional reportable disease surveillance, vital statistics, and disease registries.

21

Screening

- Defined: The identification of an unrecognized disease or defect by the application of tests, examinations, or other procedures. Screening tests sort out apparently well persons, who probably have a disease from those persons who probably do not.

Outbreak investigation

- Defined: A multi-step process for determining the dynamics of a disease outbreak and implementing control and prevention measures. Keys to determining an outbreak: • Two or more cases of a disease that are epidemiologically linked. • In some instances of rare diseases or those with high public health impact, one case is enough to qualify as an outbreak (such as botulism). • Syndromic surveillance data alerts the epidemiologist to changes in expected disease patterns.

Assessing Causation

- It is vital that information gathered through screening and surveillance is entered into a common reporting system that can be accessed by epidemiologists and healthcare practitioners statewide.

22

Epidemiological Concepts

- **Populations**: Epidemiology studies groups of people rather than with individuals.
- **Distribution**: Epidemiologists study the distribution of frequencies and patterns of health events within groups in a population. Using descriptive epidemiology, epidemiologists characterize health events in terms of time, place, and person.
- **Determinants**: Epidemiologists search for causes or factors that are associated with increased risk or probability of disease.
- **Health-Related States**: Early epidemiological study focused solely on infectious diseases. Today epidemiology studies a variety of health-related events, which includes chronic disease, environmental problems, behavioral problems, and injuries, in addition to infectious disease.
- **Exposure**: Having a certain feature that is being studied. For example, in a study on alcohol consumption, people who drink alcohol are considered the "exposed" group, while non-drinkers are considered the "unexposed" group. There is a wide variety of "exposure" to consider when studying a disease, such as exposure related to lifestyle, behavior, occupation, employment, genetics, diet, and the use of medications.

- **Disease:** a pattern of response by a living organism to some form of invasion by a foreign substance or injury which causes an alteration of the organisms normal functioning.
  - also – an abnormal state in which the body is not capable of responding to or carrying on its normally required functions.
- **Pathogens:** organisms or substances such as bacteria, viruses, or parasites that are capable of producing diseases.
- **Pathogenesis:** the development, production, or process of generating a disease.
- **Pathogenicity:** describes the potential ability of a pathogenic substance to cause disease.
- **Susceptibility**: A state in which a person or animal is capable of being infected with a microorganism. The lack of specific protective antibody usually indicates susceptibility to that agent, although reactivation or reinfection to some agents may occur in the presence of antibody.

25

- **Infective diseases** are those which the pathogen or agent has the capability to enter, survive, and multiply in the host.
- **Virulence** The severity of disease that the agent causes in the host
- **Invasiveness** The capacity of a microorganism to enter into and grow in or upon tissues of a host.
- **Incubation period:** A period of sub-clinical or non-obvious pathologic changes following an exposure. The incubation period ends with the onset of symptoms.
- **Latent period:** The interval between disease onset and clinical diagnosis.
- **Prodromal period** The time during which a disease process has begun but is not yet clinically manifest.

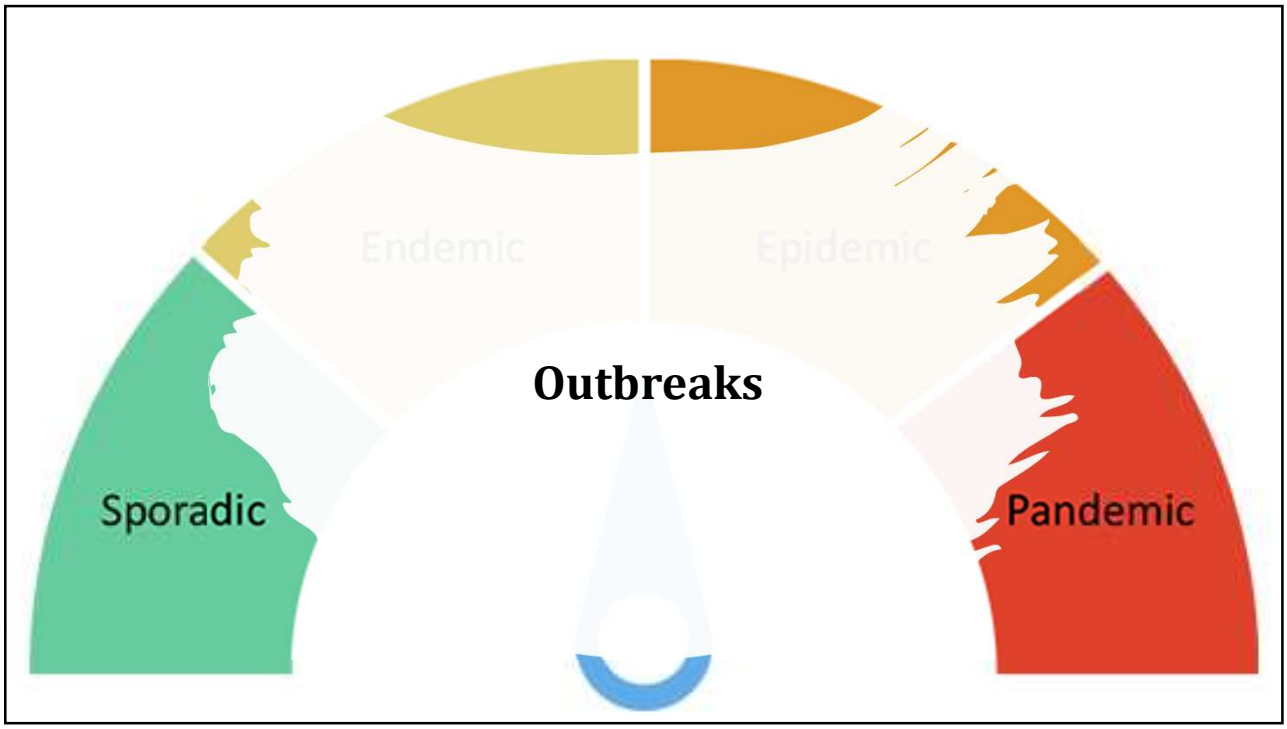
26

- **Etiology:** the factors contributing to the source of or causation of a disease.
- **Toxins:** a poisonous substance that is a specific product of the metabolic activities of a living organism and is usually very unstable.
  - notably toxic when introduced into the tissues, and typically capable of inducing antibody formation.
- **Antibiotics:** a substance produced by or a semisynthetic substance derived from a microorganism and able in dilute solution to inhibit or kill another microorganism.

27

- **Risk factors and causes:** In epidemiology the phrase 'risk factor' does not necessarily imply that the characteristic has a causal effect (association is not causation). The phrase 'risk marker' is sometimes used in preference to risk factor, simply to emphasize that no causal relationship is presumed. It has no logical advantages to counter the disadvantage of its unfamiliarity and it wrongly implies that a risk factor (rather than marker) is causal. When a causal relationship is agreed between disease and risk factor the phrase causal factor, or simply cause, is used. For example, we say smoking is a cause of coronary heart disease (CHD), but for most CHD 'risk factors' (e.g. hyperhomocystinaemia, low levels of high density lipoprotein cholesterol (HDL), high C-reactive protein, job strain) we may imply, but rarely claim, a causal role.

28



29

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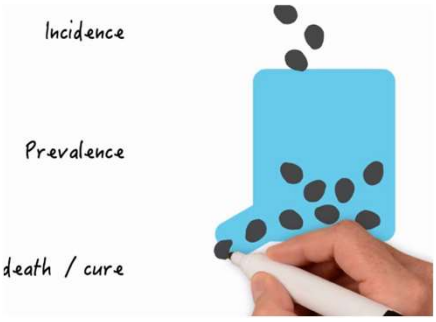
- **Endemic:** the ongoing, usual level of, or constant presence of a disease in a given population. Or, disease or condition present among a population at all times.
- **Hyperendemic:** persistent level of activity beyond or above the expected prevalence.
- **Holoendemic:** a disease that is highly prevalent in a population and is commonly acquired early in life in most all of the children of the population.
- **Epidemic:** outbreak or occurrence of one specific disease from a single source, in a group population, community, or geographical area, in excess of the usual level of expectancy.
- **Pandemic:** epidemic that is widespread across a country, continent, or large populace, possible worldwide.

30

Measures of Risk



31

Prevalence

The prevalence represents existing cases of a disease and can be seen as a measure of disease status/burden ; it is the proportion of people in a population having a disease.

$$Prevalence = \frac{Number\ of\ subjects\ having\ the\ disease\ at\ a\ time\ point}{Total\ number\ of\ subjects\ in\ the\ population}$$

32

Prevalence

- Prevalence is a useful measure of the burden of disease. Knowing about the prevalence of a specific disease can help us to understand the demands on health services to manage this disease.
- Prevalence changes when people with the condition are cured or die. Bear in mind that increased prevalence doesn't necessarily mean a bigger problem. Higher prevalence could mean a prolonged survival without cure or an increase of new cases, or both. A lower prevalence could mean that more people are dying rather than being cured, a rapid recovery, and/or a low number of new cases.

33

Incidence

- **Incidence** represents the number of new cases of a disease during a specific time period divided by the number of persons at risk for the diseases during that same time period.
- The resulting proportion can be multiplied by 1000 in order to get the number of new cases per 1000 population, or by 100 in order to get the number of new cases per 100 population.

34

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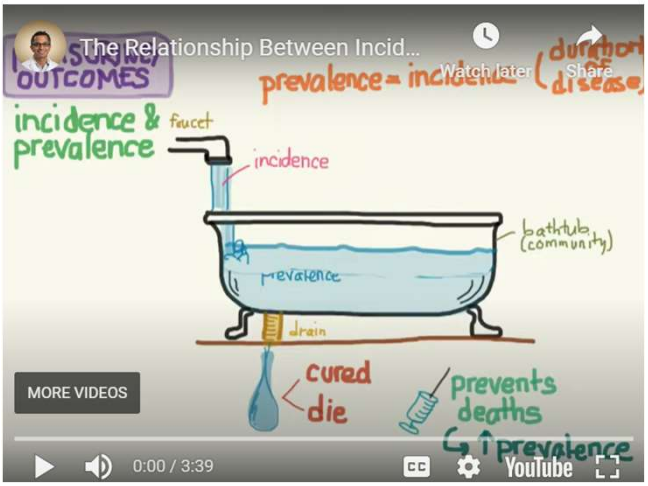


35

35

The Epidemiology Triangle

- Outbreaks in a population often involves several factor and entities.
- Many people, objects, avenues of transmission, and organisms can be involved in the spread of disease.
- Epidemiologist have created a model to help explain the multifaceted phenomena of disease transmission: the epidemiology triangle.
- Many diseases rely on an agent or single factor for an infectious disease to occur.
- Epidemiologist use an ecological view to assess the interaction of various elements and factors in the environment and disease-related implications.
- When more than a single cause must be present for a disease to occur, this is called multiple causation.

36

The Epidemiology Triangle

- The interrelatedness of 4 factors contribute to the outbreak of a disease:

1. Role of the host
2. Agent
3. Environmental circumstances
4. Time

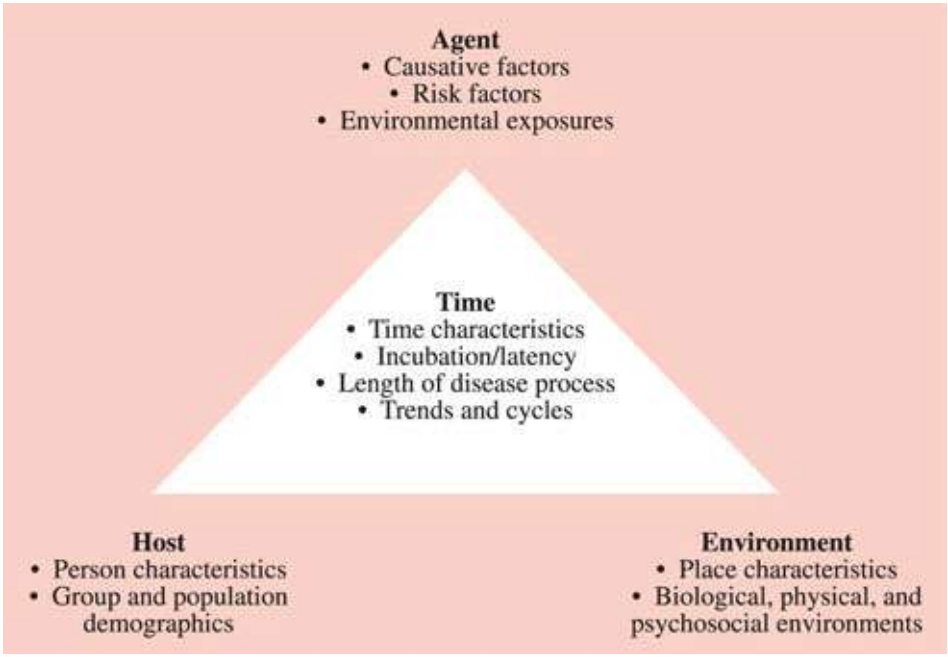
- The epidemiology triangle is used to analyze the role and interrelatedness of each of the four factors in epidemiology of infectious diseases, that is the influence, reactivity and effect each factor has on the other three.

37

The Epidemiology Triangle

- The **agent** is the cause of the disease
  - Can be bacteria, virus, parasite, fungus, mold
  - Chemicals (solvents), Radiation, heat, natural toxins (snake or spider venom)
- The **host** is an organism, usually human or animal, that harbors the disease.
  - Level of immunity, genetic make-up, state of health, and overall fitness within the host can determine the effect of a disease can have upon it.
- The **environment** is the favorable surroundings and conditions external to the human or animal that cause or allow the disease or allow disease transmission.
  - Environmental factors can include the biological aspects as well as the social, cultural, and physical aspects of the environment.
- **Time** accounts for incubation periods, life expectancy of the host or pathogen, duration of the course of illness or condition.

38



39

The Epidemiology Triangle

- The mission of the epidemiologist is to break one of the legs of the triangle, which disrupts the connection between environment, host, and agent, stopping the continuation of an outbreak.
- The goals of public health are the control and prevention of disease.
- By breaking one of the legs of the triangle, public health intervention can partially realize these goals and stop epidemics.
- An epidemic can be stopped when one of the elements of the triangle is interfered with, altered, changed or removed from existence.

40

Disease Transmission

41

Disease Transmission

- **Fomites:** inanimate objects that serve as a role in disease transmission.
  - Pencils, pens, doorknobs, infected blankets
- **Vector:** any living non-human carrier of disease that transports and serves the process of disease transmission.
  - Insects: fly, flea, mosquito; rodents; deer
- **Reservoirs:** humans, animals, plants, soils or inanimate organic matter (feces or food) in which infectious organisms live and multiply.
  - Humans often serve as reservoir and host
- **Zoonosis:** when a animal transmits a disease to a human.

42

Disease Transmission

- **Carrier:** one that spreads or harbors an infectious organism
  - Some carriers may be infected and not be sick. e.g. Typhoid Mary
  - **Mary Mallon** (1869 – 1938) was the first person in the United States to be identified as a healthy carrier of typhoid fever. Over the course of her career as a cook, she infected 47 people, three of whom died from the disease. Her notoriety is in part due to her vehement denial of her own role in spreading the disease, together with her refusal to cease working as a cook. She was forcibly quarantined twice by public health authorities and died in quarantine. It is possible that she was born with the disease, as her mother had typhoid fever during her pregnancy.

43

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Disease Transmission

- **Active carrier**: individual exposed to and harbors a disease-causing organism.
- **Convalescent carrier:** exposed to and harbors disease-causing organism (pathogen) and is in the recovery phase but is still infectious.
- **Healthy carrier:** exposed to an harbors pathogen, has not shown any symptoms.
- **Incubatory carrier:** exposed to and harbors a disease and is in the beginning stages of the disease, showing symptoms, and has the ability to transmit the disease
- **Intermittent carrier:** exposed to and harbors disease and can intermittently spread the disease
- **Passive carrier:** exposed to and harbors disease causing organism, but has no signs or symptoms

44

Modes Disease Transmission

- Modes of disease transmission
  - methods by which an agent can be passed from one host to the next
  - or can exit the host to infect another susceptible host (either person or animal)
- Two general modes
  - direct
  - indirect

45

Modes Disease Transmission

- **Direct transmission**
  - Immediate transfer of the pathogen or agent from a host/reservoir to a susceptible host
  - Can occur through direct contact such as touching contaminated hands, kissing or sex
- **Indirect transmission**
  - Pathogens or agents are transferred or carried by some intermediate item or organism, means or process to a susceptible host
  - Done in one or more following ways:
    - airborne, vehicleborne, vectorborne

46

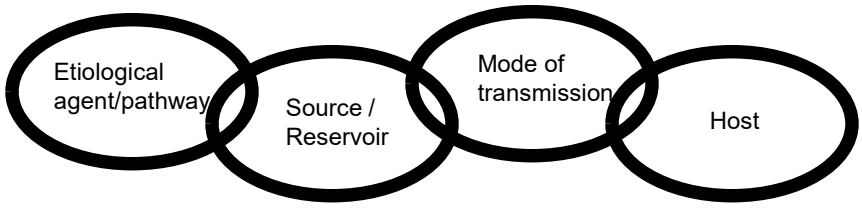
Modes Disease Transmission

- **Indirect transmission**
  - ❑Airborne
    - Agent is carried from the source to the host in air particles.
    - Sneezing, coughing, talking all spray microscopic droplets in the air
  - ❑Vehicleborne
    - Agent is carried by inanimate objects, such as food or water, blood, or items like handkerchiefs, bedding, and surgical instruments.
  - ❑Vectorborne
    - A pathogen uses a host (fly, flea, louse, or rat) as a mechanism for a ride or nourishment; this is **mechanical transmission**
    - **biological transmission** is when the pathogen undergoes changes as part of its life cycle, while within the host/vector and before being transmitted to the new host.

47

Chain of Transmission

- Close association between the triangle of epidemiology and the **chain of transmission**
- Disease transmission occurs when the **pathogen** or agent leaves the **reservoir** through a **portal or exit** and is spread by one of several **modes of transmission.**
- Breaks in the chain of transmission will stop the spread of disease



48

Levels of Disease

❖Diseases have a range of seriousness, effect, duration, severity, and extent

Classified into 3 levels:

- **Acute** relatively severe, of short duration and often treatable
  - usually the patient either recovers or dies
- **Subacute** intermediate in severity and duration, having some acute aspects to the disease but of longer duration and with a degree of severity that detracts from a complete state of health
  - Patient expected to eventually heal
- **Chronic** less severe but of long and continuous duration, lasting over a long time periods, if not a lifetime
  - Patient may not fully recover and the disease can get worse overtime
  - Life not immediately threatened, but may be over long term

49

Immunity and Immunization

- According to CDC, unless 80% or greater of the population is vaccinated, epidemics can occur.
- Three types of immunity possible in humans:
  - **Acquired Immunity** obtained by having had a dose of a disease that stimulates the natural immune system or artificially stimulating immune system.
  - **Active Immunity** body produces its own antibodies.
    - can occur through a vaccine or in response to having a similar disease
    - Similar to acquired
  - **Passive Immunity (natural passive)** acquired through transplacental transfer of a mother's immunity to diseases to the unborn child (also via breastfeeding).

50

Herd Immunity

- Herd immunity occurs when a large portion of a community (the herd) becomes immune to a disease. The spread of disease from person to person becomes unlikely when herd immunity is achieved. As a result, the whole community becomes protected — not just those who are immune.
- Herd immunity can be reached when enough people in the population have recovered from a disease and have developed protective antibodies against future infection.

51

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- When there is little to no immunity within a population, the disease spreads quickly.

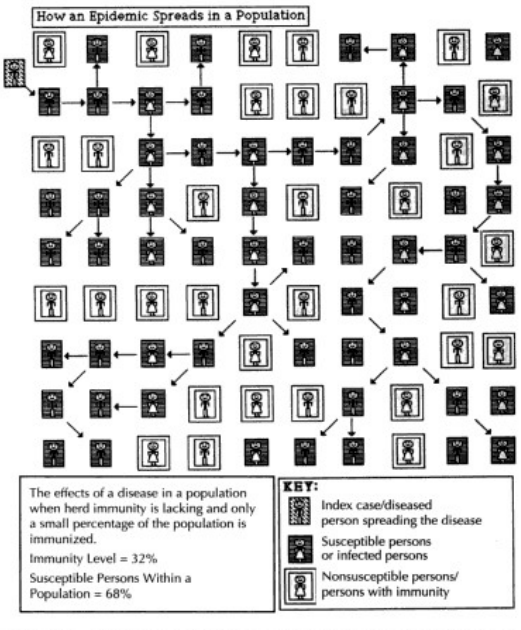

FIGURE 2.8 Diagram of a population, showing a low immunization level which falls short of protecting individuals within the group.

52

Herd Immunity

- the resistance a population or group (herd) has to the invasion and spread of an infectious disease

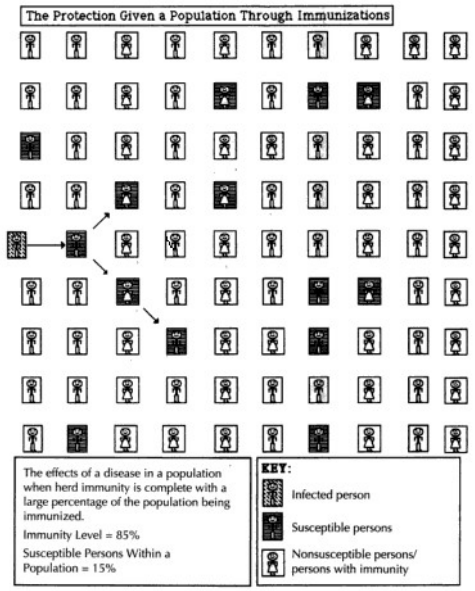

FIGURE 2.9 Diagram of a population showing a high level of immunizations within the group so that it affords a good level of protection to most of the individuals within the group.

53

End of Topic

54