Introduction to Epidemiology

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What is Epidemiology?

- The word **epidemiology** comes from the Greek words **epi**, meaning “on or upon,” **demos**, meaning “people,” and **logos**, meaning “the study of.” Many definitions have been proposed, but the following definition captures the underlying principles and the public health spirit of epidemiology:
- “Epidemiology is the **study** of the **distribution** and **determinants of health-related states or events** in **specified populations**, and the **application** of this study to the control of health problems.”

Epidemiology cont'd ….

- epidemiologists study sick people
- epidemiologists study healthy people
- to determine the crucial difference between those who get the disease and those who are spared
- epidemiologists study exposed people
- epidemiologists study non-exposed people
- to determine the crucial effect of the exposure

Uses of Epidemiology

- to determine, describe, and report on the natural course of disease, disability, injury, and death
- to aid in the planning and development of health services and programs
- to provide administrative and planning data

Uses of Epidemiology cont'd…

- to study the cause (or etiology) of disease(s), or conditions, disorders, disabilities, etc.
- to determine the primary agent responsible or ascertain causative factors
- to determine the characteristics of the agent or causative factors
- to determine the mode of transmission
- to determine contributing factors
- to identify and determine geographic patterns

Purpose of Epidemiology

- to provide a basis for developing disease control and prevention measures for groups at risk
- this translates into developing measures to prevent or control disease

Two Broad Types of Epidemiology:

- **descriptive epidemiology**: examining the distribution of disease in a population, and observing the basic features of its distribution
- **analytic epidemiology**: investigating a hypothesis about the cause of disease by studying how exposures relate to disease

descriptive epidemiology is antecedent to analytical epidemiology:

analytical epidemiology studies require information to ...

- ✓ know **where** to look
- ✓ know **what** to control for
- ✓ develop **viable hypotheses**

Descriptive Cont’d…..

three essentials characteristics of disease that we look for in descriptive studies are ...

- ✓Person
- ✓Place
- ✓Time

Person

- age, gender, ethnic group
- genetic predisposition
- concurrent disease
- diet, physical activity, smoking
- risk taking behavior
- Socio-economic status, education, occupation

Geographic Place

- presence of agents or vectors
- Climate
- Geology
- population density
- economic development
- nutritional practices
- medical practices

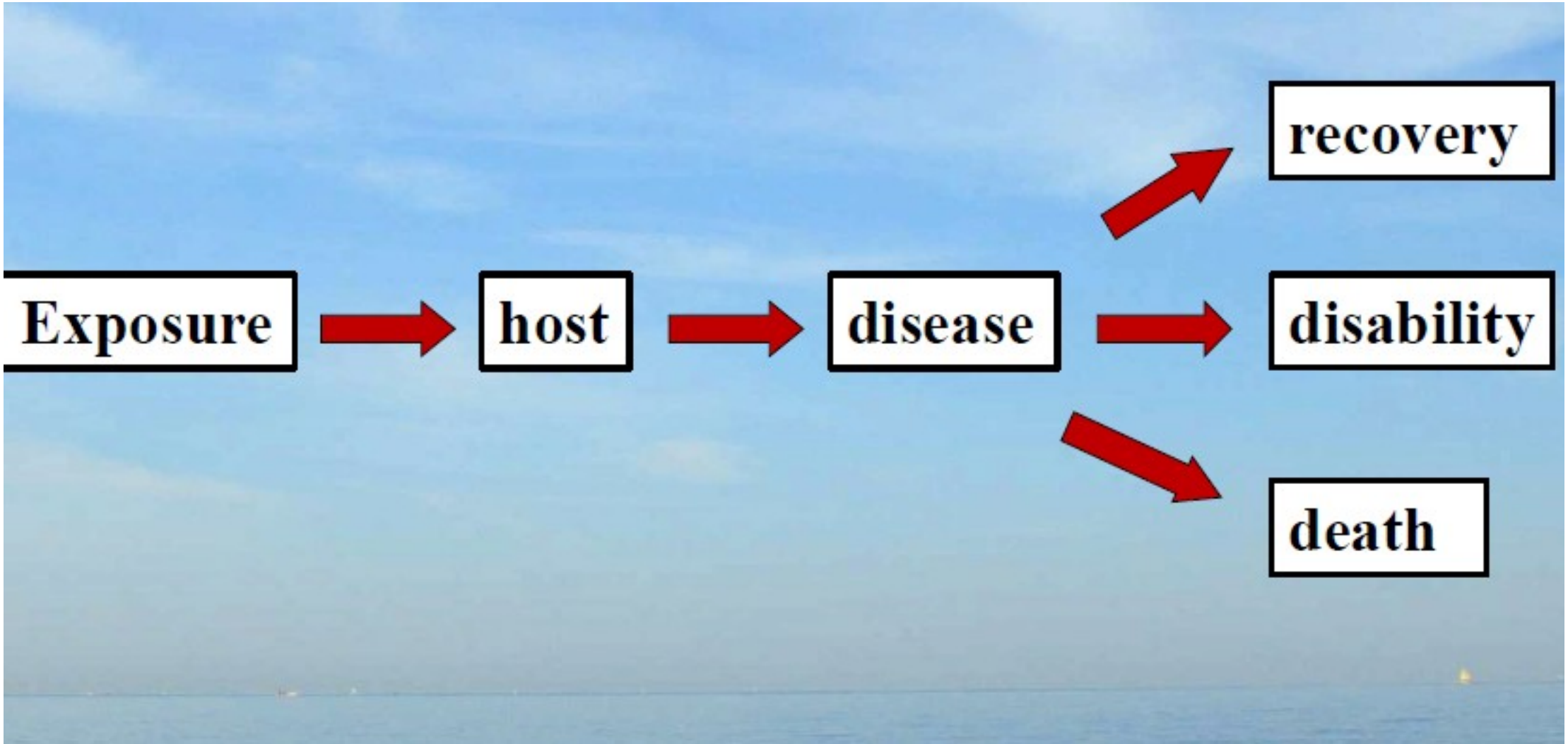
Time

- calendar time
- time since an event
- physiologic cycles
- age (time since birth)
- Seasonality
- temporal trends

Natural history of diseases

- **Natural history** of disease refers to the progress of a disease process in an individual over time, in the absence of intervention.
- The process begins with exposure to or accumulation of factors capable of causing disease.
- Without medical intervention, the process ends with
  - ✓ recovery ,
  - ✓ disability,
  - ✓ or death.

Natural history of disease cont'd…



Natural history of disease cont’d…

- Knowledge of the natural history of disease ranks alongside causal understanding in importance for disease prevention and control.
- Natural history of disease is one of the major elements of descriptive epidemiology

Natural history of disease cont’d…

- The natural history of disease is best established by cohort studies.
- As these studies are costly and laborious, understanding of the natural history of disease is largely based on other epidemiological studies, such as cross-sectional and retrospective studies, undertaken in different population settings.

Natural history of disease cont’d…

- What the physician sees in the hospital is just an "episode" in the natural history of disease.
- The epidemiologist, by studying the natural history of disease in the community setting is in a unique position to fill the gaps in the knowledge about the natural history of disease

Natural history of disease cont'd…

- The natural history and spectrum of disease presents challenges to the clinician and to the public health worker.
- Because of the clinical spectrum, cases of illness diagnosed by clinicians in the community often represent only the "tip of the iceberg." Many additional cases may be too early to diagnose or may remain asymptomatic.
- For the public health worker, the challenge is that persons with undiagnosed infections may nevertheless be able to transmit them to others.

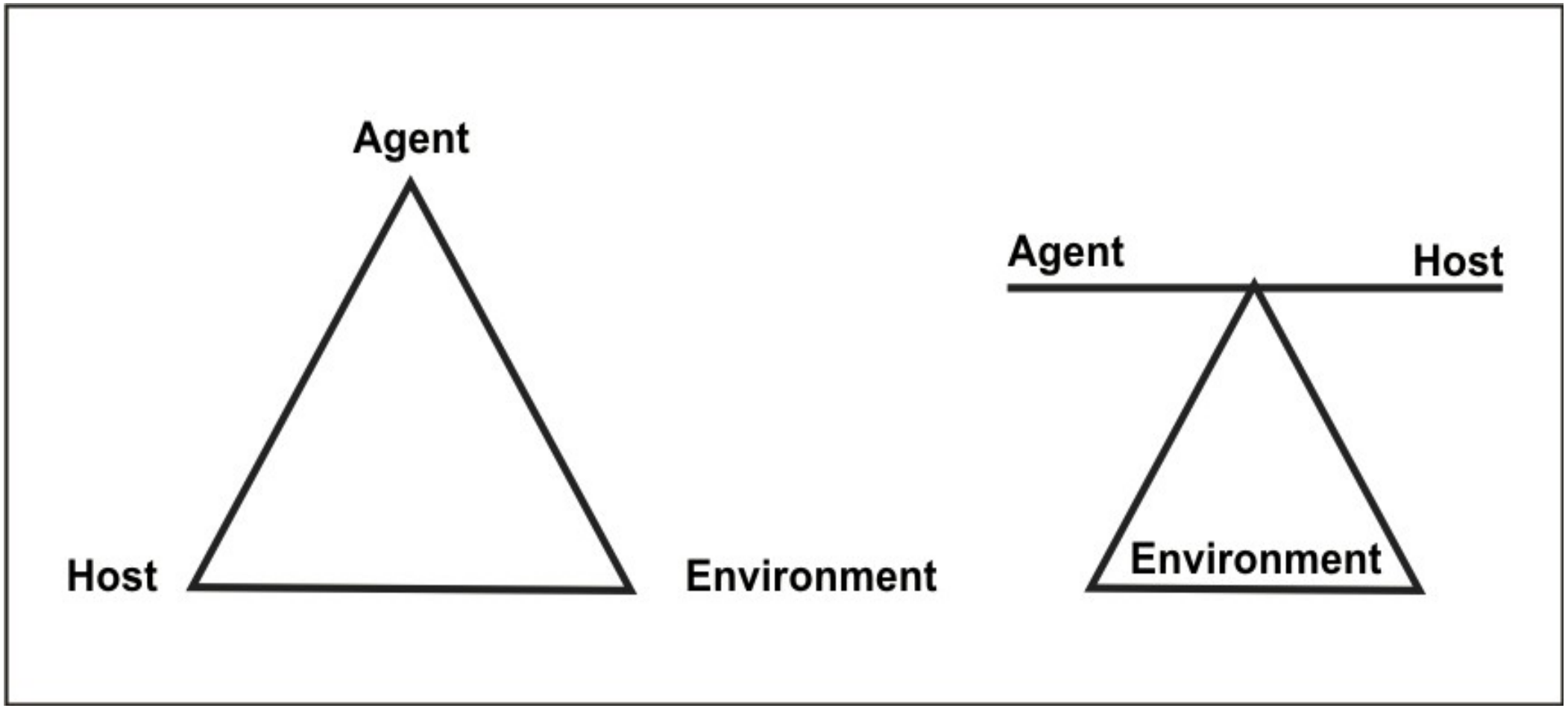
Concepts of disease causation

- Germ theory of disease
- Epidemiological Triad
- BEINGS theory
- Web of Causation theory

Germ Theory of Disease

- Proposed by Robert Koch and Louis Pasteur.
- Every human disease is caused by a microbe or germ, which is specific for that disease and one must be able to isolate the microbe from the diseased human being

Epidemiologic Triad:
Agent, Host, and Environment



Agent

- Is an element or substance, animate or inanimate, the presence (or absence) of which may initiate or perpetuate a disease process.
- A disease may have a single agent, a number of independent alternative agents or complex of two or more factors whose combined presence is essential for the development of the disease.

Agent cont’d…..

Classification of agents:

- ✓ Biological
- ✓ Nutrient
- ✓ Physical
- ✓ Chemical
- ✓ Mechanical
- ✓ Absence or insufficiency or excess of a factor necessary to health
- ✓ Social

Agent characteristics

- **Infectivity** refers to the proportion of exposed persons who become infected.
- **Pathogenicity** refers to the proportion of infected persons who develop clinical disease.
- **Virulence** refers to the proportion of persons with clinical disease who become severely ill or die.

Agent characteristics cont'd…

- Hepatitis A virus in children has low pathogenicity and low virulence, since many infected children remain asymptomatic and few develop severe illness.
- In persons with good nutrition and health, measles virus has high pathogenicity but low virulence, since almost all infected persons develop the characteristic rash and illness but few develop the life threatening presentations of measles (pneumonia, encephalitis).
- In persons with poor nutrition and health, measles is a more virulent disease, with mortality as high as 5-10%.
- Rabies virus is both highly pathogenic and virulent, since virtually 100% of all infected persons (who do not receive treatment) progress to clinical disease and death.

Host

- In epidemiological terminology, the human host is referred to as “soil” and the disease agent as “seed”.
- A person or other living animal, that affords subsistence or lodgment to an infectious agent under natural condition.
- **Host factor**s: Intrinsic factors that influence an individual’s exposure, susceptibility, or response to a causative agent

Environment

- Physical environment
  - ✓ Non living things and physical factors(air, water, soil, housing, heat, light, etc)
- Biological environment
  - ✓ Microbial agents, insects, animals, plants and man himself.
- Psychosocial environment
  - ✓ Lifestyle, poverty, urbanization, community life, income, education, stress etc.

Disease Occurrence

Different diseases, in different communities, show different patterns of expected occurrence:

- **Endemic**: habitual presence of a disease within a given geographic area.
- **Hyperendemic** :a persistently high level of occurrence.
- **Sporadic** : an irregular pattern of occurrence, with occasional cases occurring at irregular intervals.(prevalence is zero)

Disease Occurrence cont'd….

- **Epidemic**: occurrence in a community or region of a group of illnesses of similar nature, clearly in excess of normal expectancy and derived from a common or from a propagated source.
- Public health officials often use the term **outbreak**, which means the same, because it is less provocative to the public.
- When an epidemic spreads over several countries or continents, affecting a large number of people, it is called a **pandemic(worldwide epidemic**).

The “BEINGS” Model of Disease Causation

This concept postulates that human disease and its consequences are caused by a complex interplay of nine different factors –

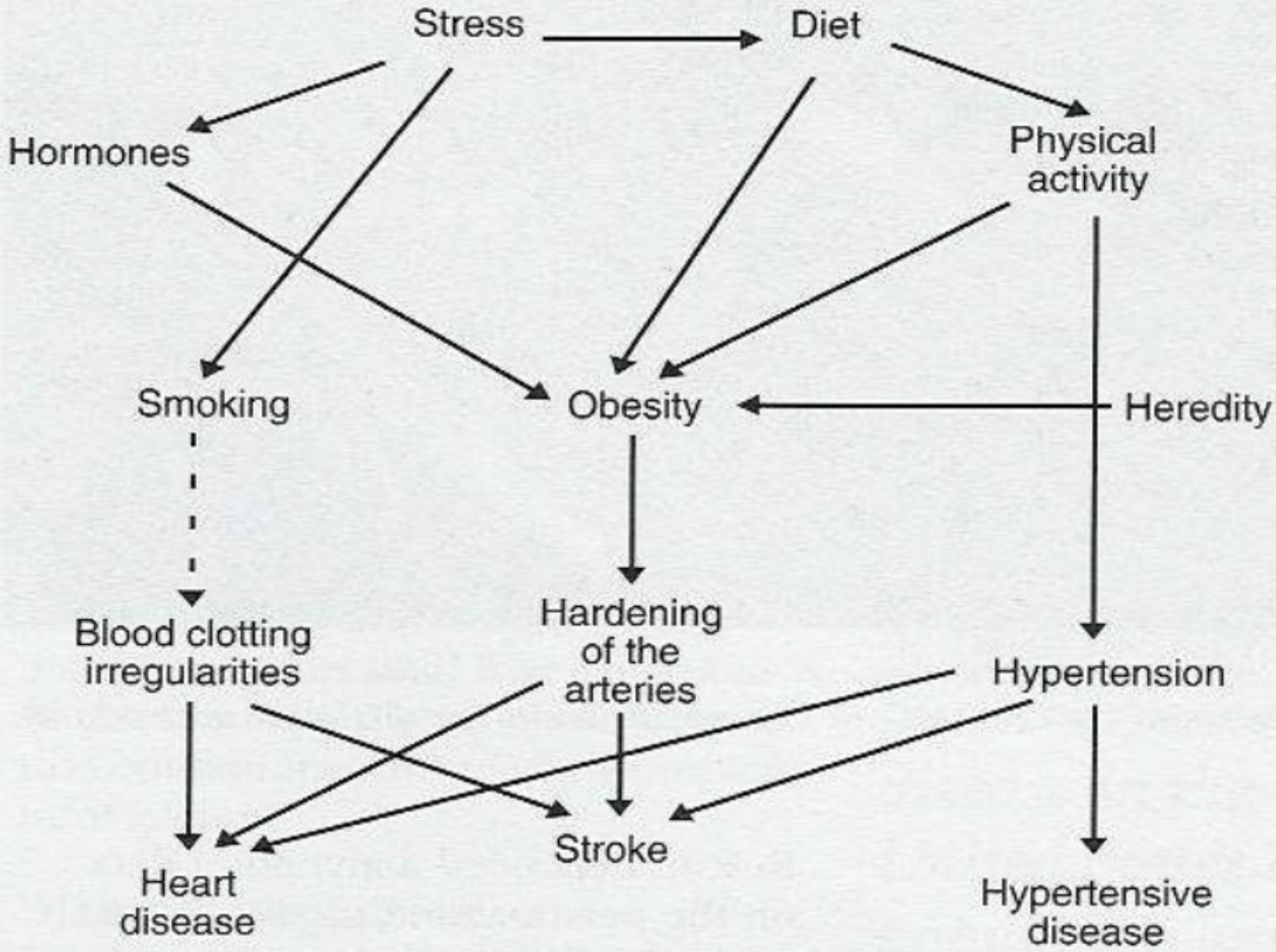
- ✓ **B**iological factors innate in a human being,
- ✓ **Behavioral** factors concerned with individual lifestyles,
- ✓ **E**nvironmental factors as physical, chemical and biological aspects of environment,
- ✓ Immunological factors,
- ✓ **N**utritional factors,
- ✓ **G**enetic factors,
- ✓ **S**ocial factors,
- ✓ **S**piritual factors and
- ✓ **S**ervices factors, related to the various aspects of health care services

Theory of “Web of Causation”

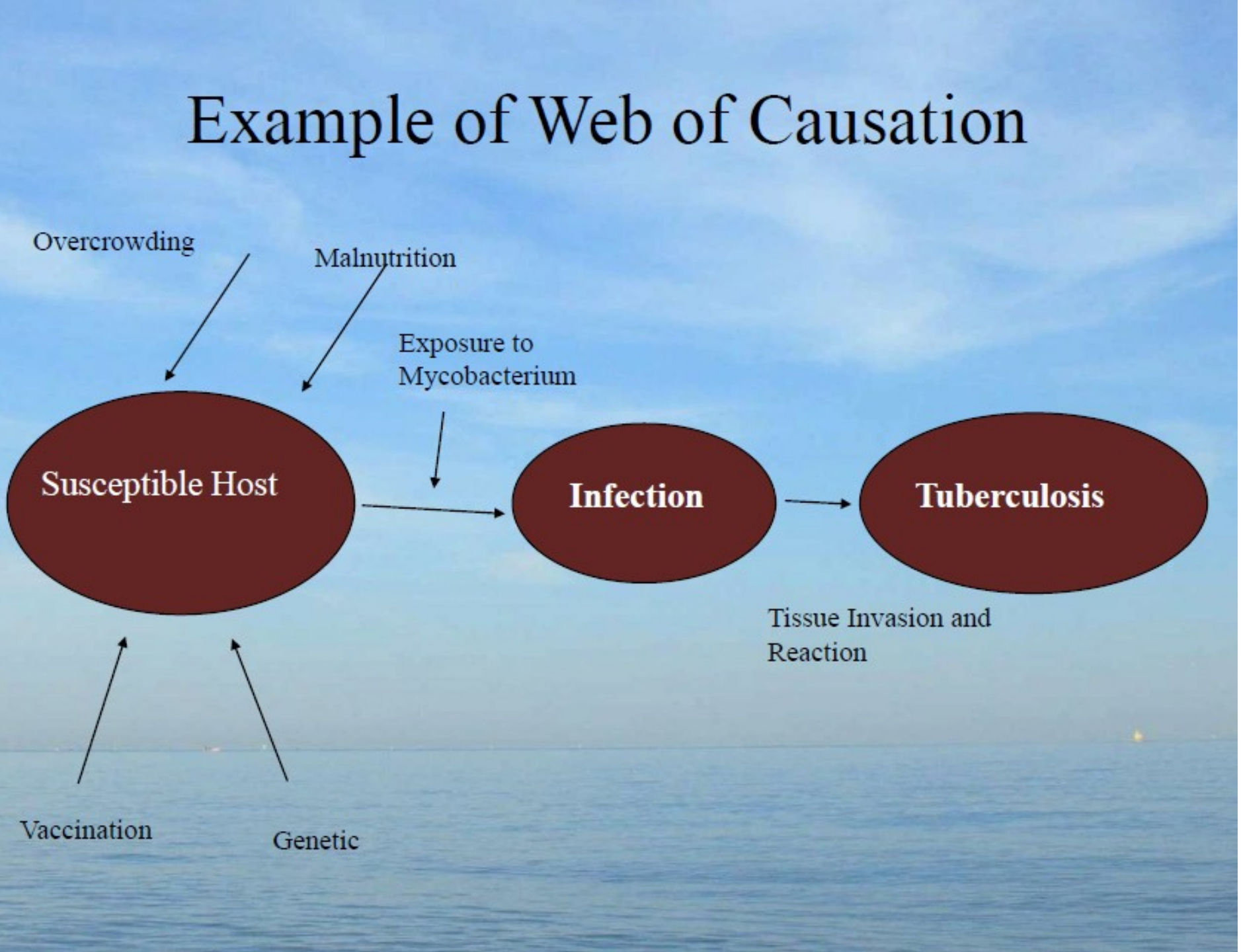
- The “epidemiological triad theory” was very effectively used by Leavel and Clark in explaining the natural history of disease and levels of prevention for obviating such departures from the state of health
- But it could not explain the causation of non communicable diseases like Ischemic heart disease or road accidents.

Web of causation

- McMahon and Pugh forwarded the theory of “epidemiological web of causation”, wherein the various factors (e.g. hypercholesterolemia, smoking, hypertension) are like an interacting web of a spider.
- Each factor has its own relative importance in causing the final departure from the state of health, as well as interacts with others, modifying the effect of each other.


Stress
Diet
Hormones
Physical activity
Smoking
Obesity
Heredity
Blood clotting irregularities
Hardening of the arteries
Hypertension
Heart disease
Stroke
Hypertensive disease

Example of Web of Causation



Application of the Web

Epidemiologic Triad

- devised to enhance search for understanding communicable disease

Web of Causation

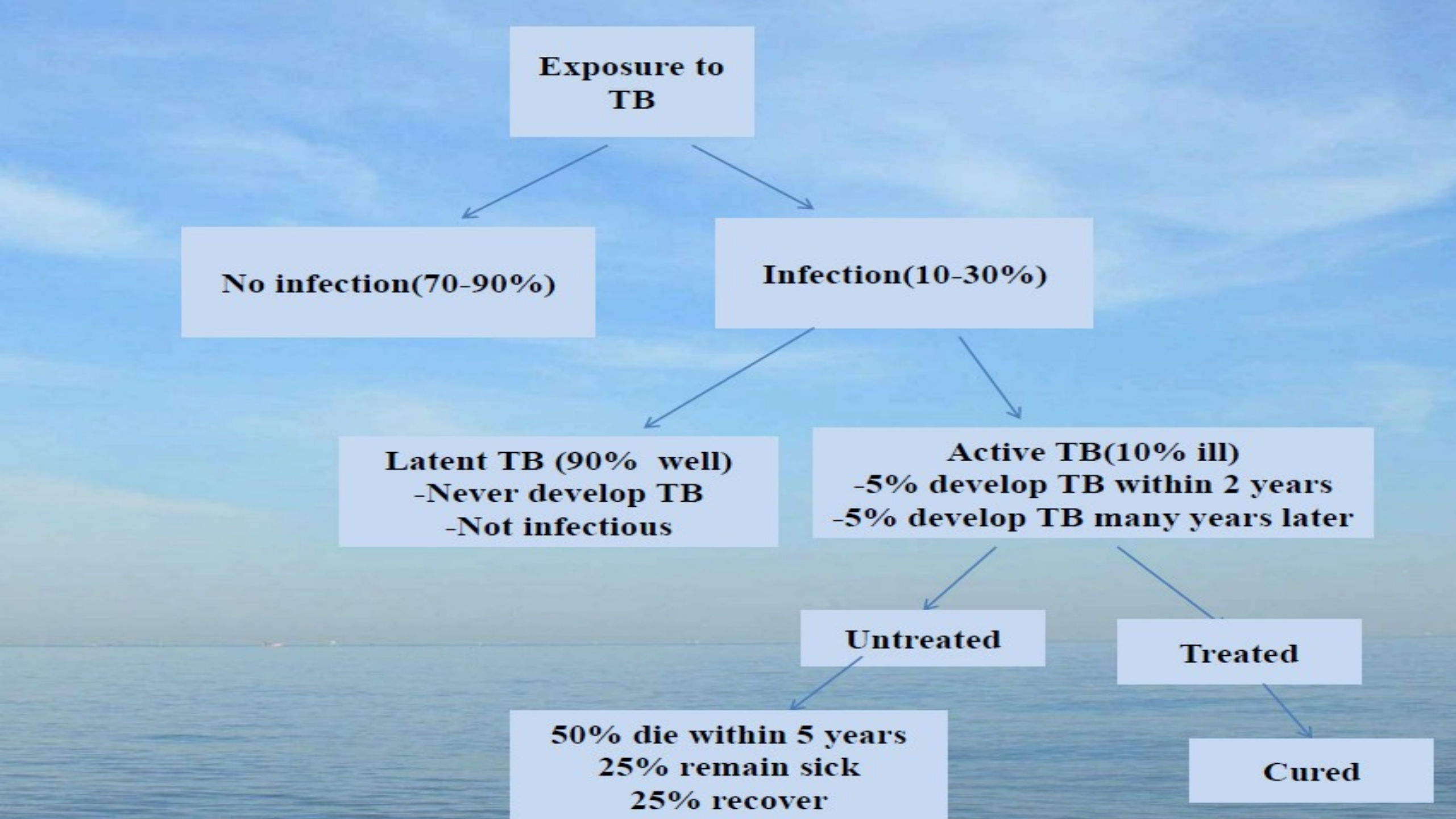
- devised to address non-communicable diseases – can also be applied to communicable disease

Factors of disease causation

- **Predisposing factors** are factors which create a state of susceptibility, so that the host becomes vulnerable to the agent or to necessary cause, e.g. age, sex, previous illness.
- **Enabling factors** are those which assist in the development of (or in recovery from) the disease; e.g. housing conditions, socio-economic status.
- **Precipitating factors** are those which are associated with immediate exposure to the disease agent or onset of disease, e.g. drinking contaminated water, close contact with a case of pulmonary TB.

Factors of disease causation cont'd…

- **Reinforcing factors** are those which aggravate an already existing disease, e.g. malnutrition, repeated exposures
- **Risk factors** : A risk factor is defined as a condition, quality or attribute, the presence of which increases the chances of an individual to have, develop or be adversely affected by a disease process. A risk factor is not necessarily the cause of a disease but does increase the probability that a person exposed to the factor may get the disease.


Exposure to TB
No infection(70-90%)
Infection(10-30%)
Latent TB (90% well)
-Never develop TB
-Not infectious
Active TB(10% ill)
-5% develop TB within 2 years
-5% develop TB many years later
Untreated
Treated
50% die within 5 years
25% remain sick
25% recover
Cured

Establishing cause of disease

- Causal inference is the term for the process of working out whether observed associations are likely to be causal

Establishing cause of disease cont'd ….

- Recognizing the short comings of Koch's postulates, epidemiologists in the 20th century required a more systematic approach to establishing cause and effect relationships
  - ✓US Surgeon General (1964) used this approach to establish cigarette smoking caused lung cancer
  - ✓This approach further elaborated by Bradford Hill (1965) in a set of 'guideline for causation'

Causal “Guidelines” suggested by Sir AB Hill (1965)

- ✓Temporality
- ✓Plausibility/Coherence
- ✓Consistency
- ✓Strength of association
- ✓Biological gradient/dose response relationship
- ✓Reversibility/Experiment
- ✓Analogy/Study Design
- ✓Specificity

Causal “Guidelines” suggested by Sir AB Hill (1965)

Purpose: Guidelines to help determine if associations are causal. Should not be used as rigid criteria to be followed slavishly. Hill even stated he did not intend for these “viewpoints” to be used as “hard and fast rules.”

Temporality

- The causal factor must precede the disease in time
- This is the only one of Hill’s criteria that every one agree with

Temporality cont’d…

- Prospective studies do a good job establishing the correct temporal relationship between an exposure and a disease
- Eg. A prospective cohort study of smokers and non-smokers starts with the two groups when they are healthy and follows them to determine the occurrence of subsequent lung cancer

Plausibility/Coherence

- Biological or social model exists to explain the association. Association does not conflict with current knowledge of natural history and biology of disease
- Eg. Cigarettes contain many carcinogenic substances
- Many epidemiologic studies have identified cause-effect relationships before biological mechanism were identified. For Eg, the carcinogenic substances in cigarette smoke were discovered after the initial epidemiologic studies linking smoking to cancer.

Consistency

- The association is observed repeatedly in different persons, places, times, and circumstances
- Replicating the association in different samples, with different study designs, and different investigators gives evidence of causation
- Eg: Smoking has been associated with lung cancer in at least 29 retrospective and 7 prospective studies

Strength of the association

- The larger the association, the more likely the exposure is causing the disease
- Eg: Relative risk of lung cancer in smokers vs. non-smokers = 9; Relative risk of lung cancer in heavy vs. non-smokers = 20
- Strong associations are more likely to be causal b/c they are unlikely to be due entirely to bias and cofounding
- Weak associations may be causal but it is harder to rule out bias and confounding

Biological gradient/Dose- response relationship

- A “dose-response” relationship between exposure and disease. Persons who have increasingly higher exposure levels have increasingly higher risks of disease
- Eg: Lung cancer death rates rise with the number of cigarette smoked
- Some exposures might not have a “dose-response” effect but rather a “threshold effect” below which these are no adverse outcomes

Experiment/Reversibility

- Investigator-initiated intervention that modifies the exposure through prevention, treatment or removal should result in less disease
- Eg: Smoking cessation programs lower in lung cancer rates
- Provides strong evidence for causation, but most epidemiologic studies are observational

Analogy/Study design

- Has a similar relationship been observed with another exposure and /or a disease?
- Is the evidence based on a strong study design
- Eg: Effects of Thalidomide and Rubella on the fetus provide analogy for effects of similar substances on the fetus

Specificity

- A single exposure should cause a single disease
- This is a hold-over from the concepts of causation that were developed for infectious diseases
- Eg: Smoking is associated with lung cancer as well as many other diseases. In addition, lung cancer results from smoking as well as other exposures
- When present, specificity dose provide evidence of causality, but its absence dose not preclude causation

Conclusion

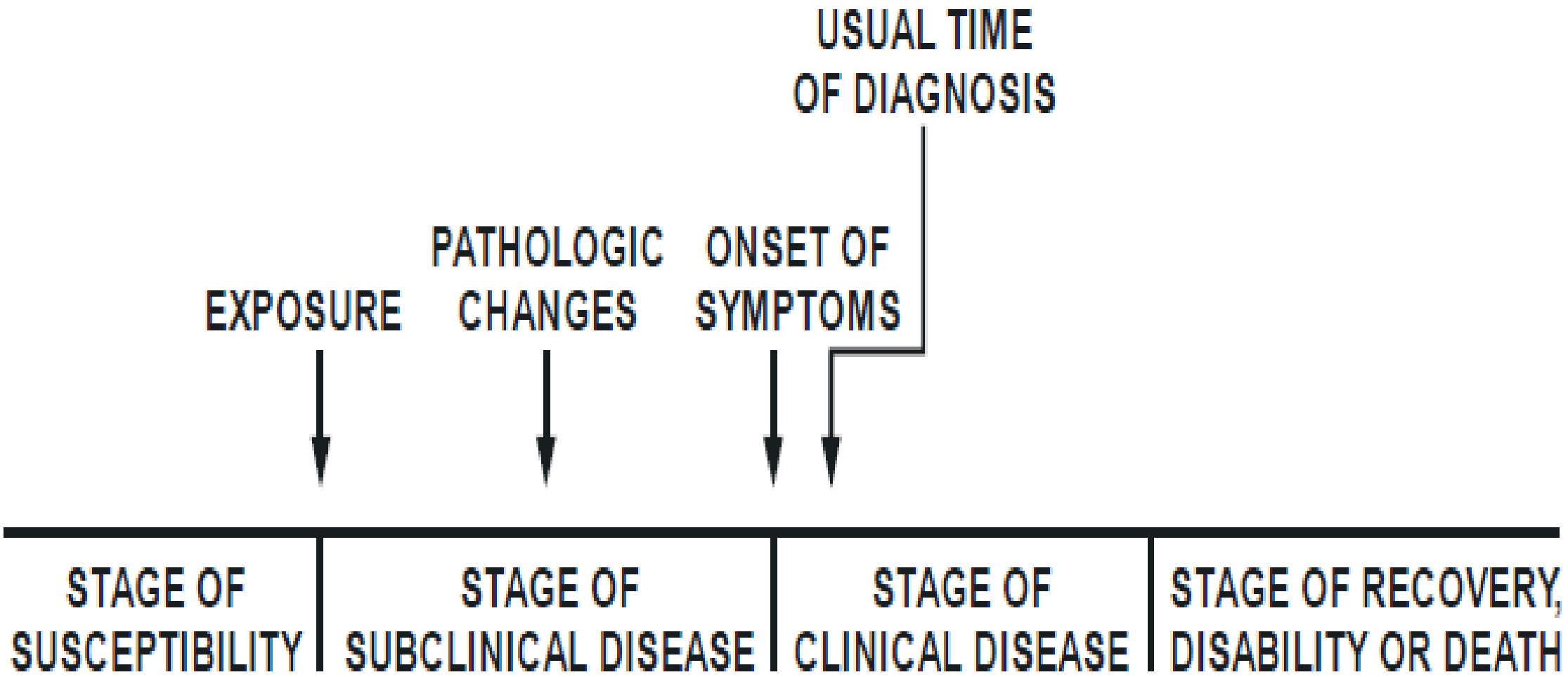
- There is no completely reliable criteria for guiding the result.

- It is tentative and uncertainty remain must important guideline is temporal relation, plausibility, study design, consistency etc

Natural History and Spectrum of Disease in patient

- **Natural history** of disease refers to the progress of a disease process in an individual over time, in the absence of intervention.
- The process begins with exposure to or accumulation of factors capable of causing disease.
- Without medical intervention, the process ends with recovery, disability, or death.

Natural history of disease



Natural History cont'd …..

- After the disease process has been triggered, pathological changes then occur without the individual being aware of them. This stage of **subclinical disease**, extending from the time of exposure to onset of disease symptoms, is usually called the **incubation period** for infectious diseases, and the **latency period** for chronic diseases
- During this stage, disease is said to be **asymptomatic** (no symptoms) or **in-apparent**. This period may be as brief as seconds for hypersensitivity and toxic reactions to as long as decades for certain chronic diseases. Even for a single disease, the characteristic incubation period has a range

Natural History cont'd …..

- Although disease is not apparent during the incubation period, some pathologic changes may be detectable with laboratory, radiographic, or other screening methods
- The onset of symptoms marks the transition from subclinical to clinical disease. Most diagnoses are made during the stage of clinical disease

Natural History cont'd …..

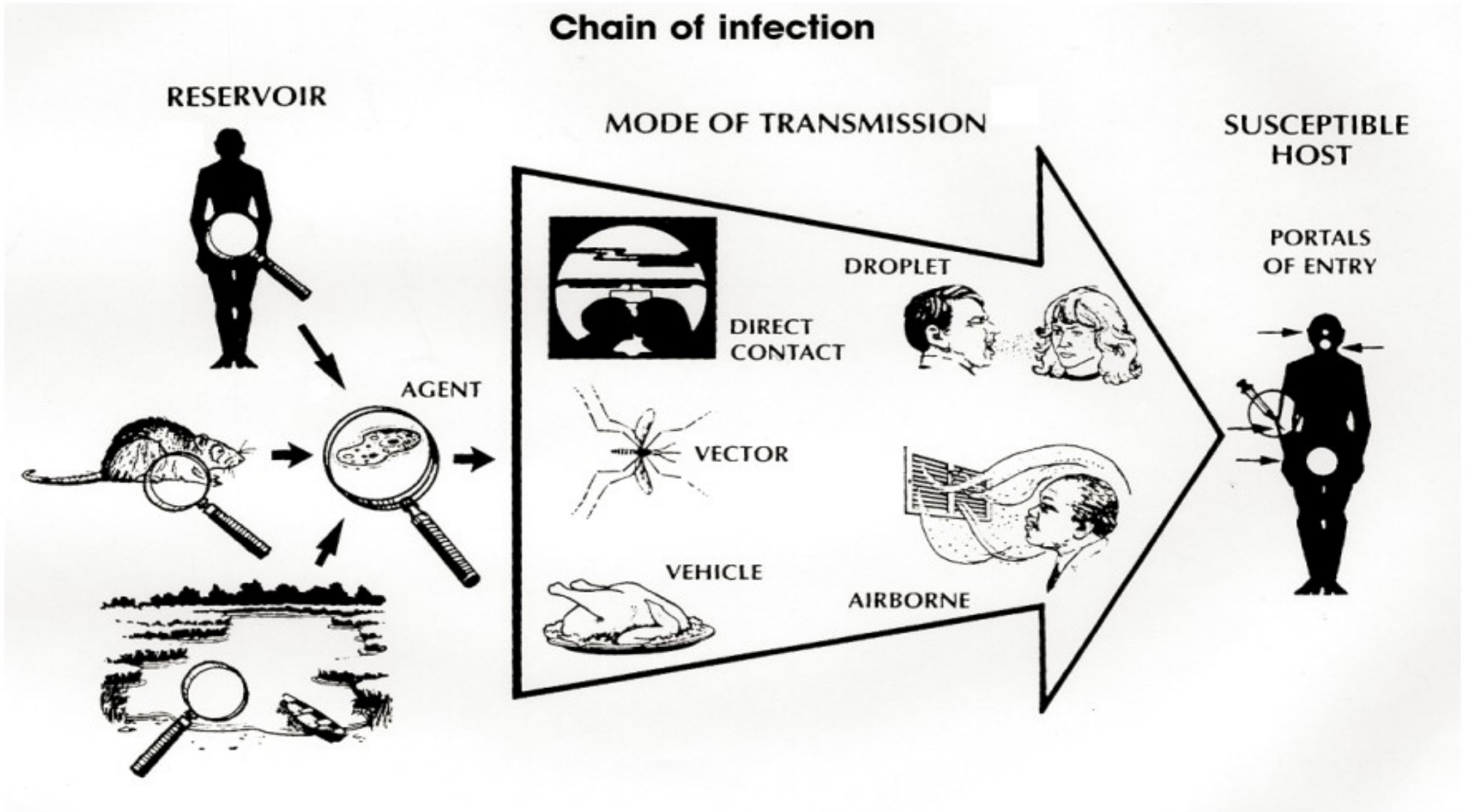
- In some people, however, the disease process may never progress to clinically apparent illness.
- In others, the disease process may result in illness that ranges from mild to severe or fatal. This range is called the **spectrum of disease**. Ultimately, the disease process ends either in recovery, disability or death
- For an infectious agent, **infectivity** refers to the proportion of exposed persons who become infected

Natural History cont'd …..

- **Pathogenicity** refers to the proportion of infected individuals who develop clinically apparent disease.
- **Virulence** refers to the proportion of clinically apparent cases that are severe or fatal

Chain of Infection

- the traditional epidemiologic triad model holds that infectious diseases result from the interaction of agent, host, and environment.
- transmission occurs when the agent leaves its **reservoir** or host through a **portal of exit**, is conveyed by some **mode of transmission**, and enters through an appropriate **portal of entry** to infect a **susceptible host**. This sequence is sometimes called the chain of infection


Chain of infection
RESERVOIR
AGENT
MODE OF TRANSMISSION
DIRECT CONTACT
DROPLET
VECTOR
VEHICLE
AIRBORNE
SUSCEPTIBLE HOST
PORTALS OF ENTRY

Reservoir

- The reservoir of an infectious agent is the habitat in which the agent normally lives, grows, and multiplies.
- Reservoirs include **humans**, **animals**, and the **environment.**
- The reservoir may or may not be the source from which an agent is transferred to a host
- For example, the reservoir of *Clostridium botulinum* is soil, but the source of most botulism infections is improperly canned food containing *C. botulinum* spores

Portal of exit

- Portal of exit is the path by which a pathogen leaves its host.
- The portal of exit usually corresponds to the site where the pathogen is localized
- For example, influenza viruses and *Mycobacterium tuberculosis* exit the respiratory tract, schistosomes through urine, cholera vibrios in feces
- Some bloodborne agents can exit by crossing the placenta from mother to fetus (rubella, syphilis, toxoplasmosis), while others exit through cuts or needles in the skin (hepatitis B) or blood-sucking arthropods (malaria)

Modes of transmission

- An infectious agent may be transmitted from its natural reservoir to a susceptible host in different ways

  - Direct
    - Direct contact
    - Droplet spread
  - Indirect
    - Airborne
    - Vehicle borne
    - Vector borne (mechanical or biologic)

Modes of transmission cont'd…..

- **direct transmission**, an infectious agent is transferred from a reservoir to a susceptible host by direct contact or droplet spread
  - **Direct contact** occurs through skin-to-skin contact, kissing, and sexual intercourse.
  - Direct contact also refers to contact with soil or vegetation harboring infectious organisms
  - **Droplet spread** *r*efers to spray with relatively large, short-range aerosols produced by sneezing, coughing, or even talking.
  - Droplet spread is classified as direct because transmission is by direct spray over a few feet, before the droplets fall to the ground

Modes of transmission cont'd…..

- **Indirect transmission** refers to the transfer of an infectious agent from a reservoir to a host by suspended air particles, inanimate objects (vehicles), or animate intermediaries (vectors).
  - **Airborne** transmission occurs when infectious agents are carried by dust or droplet nuclei suspended in air.
  - Airborne dust includes material that has settled on surfaces and become resuspended by air currents as well as infectious particles blown from the soil by the wind

Modes of transmission cont'd…..

- **Vehicles** that may indirectly transmit an infectious agent include food, water, biologic products (blood), and fomites (inanimate objects such as handkerchiefs, bedding, or surgical scalpels).
- A vehicle may passively carry a pathogen — as food or water may carry hepatitis A virus.
- the vehicle may provide an environment in which the agent grows, multiplies, or produces toxin — as improperly canned foods provide an environment that supports production of botulinum toxin by *Clostridium botulinum*

Modes of transmission cont'd…..

- **Vectors** such as mosquitoes, fleas, and ticks may carry an infectious agent through purely mechanical means or may support growth or changes in the agent.
- Examples of mechanical transmission are flies carrying *Shigella* on their appendages and fleas carrying *Yersinia pestis*, the causative agent of plague, in their gut.
- In contrast, in biologic transmission, the causative agent of malaria or guinea worm disease undergoes maturation in an intermediate host before it can be transmitted to humans

Portal of entry

- The portal of entry refers to the manner in which a pathogen enters a susceptible host.
- The portal of entry must provide access to tissues in which the pathogen can multiply or a toxin can act.
- Often, infectious agents use the same portal to enter a new host that they used to exit the source host. For example, influenza virus exits the respiratory tract of the source host and enters the respiratory tract of the new host.
- In contrast, many pathogens that cause gastroenteritis follow a so-called “fecal-oral” route because they exit the source host in feces, are carried on inadequately washed hands to a vehicle such as food, water, or utensil, and enter a new host through the mouth

Host

- The final link in the chain of infection is a susceptible host.
- Susceptibility of a host depends on genetic or constitutional factors, specific immunity, and nonspecific factors that affect an individual’s ability to resist infection or to limit pathogenicity.
- An individual’s genetic makeup may either increase or decrease susceptibility
- Specific immunity refers to protective antibodies that are directed against a specific agent. Such antibodies may develop in response to infection, vaccine, or toxoid or may be acquired by transplacental transfer from mother to fetus or by injection of antitoxin or immune globulin

Host cont’d…..

- Nonspecific factors that defend against infection include the skin, mucous membranes, gastric acidity, cilia in the respiratory tract, the cough reflex, and nonspecific immune response.
- Factors that may increase susceptibility to infection by disrupting host defenses include malnutrition, alcoholism, and disease or therapy that impairs the nonspecific immune response