

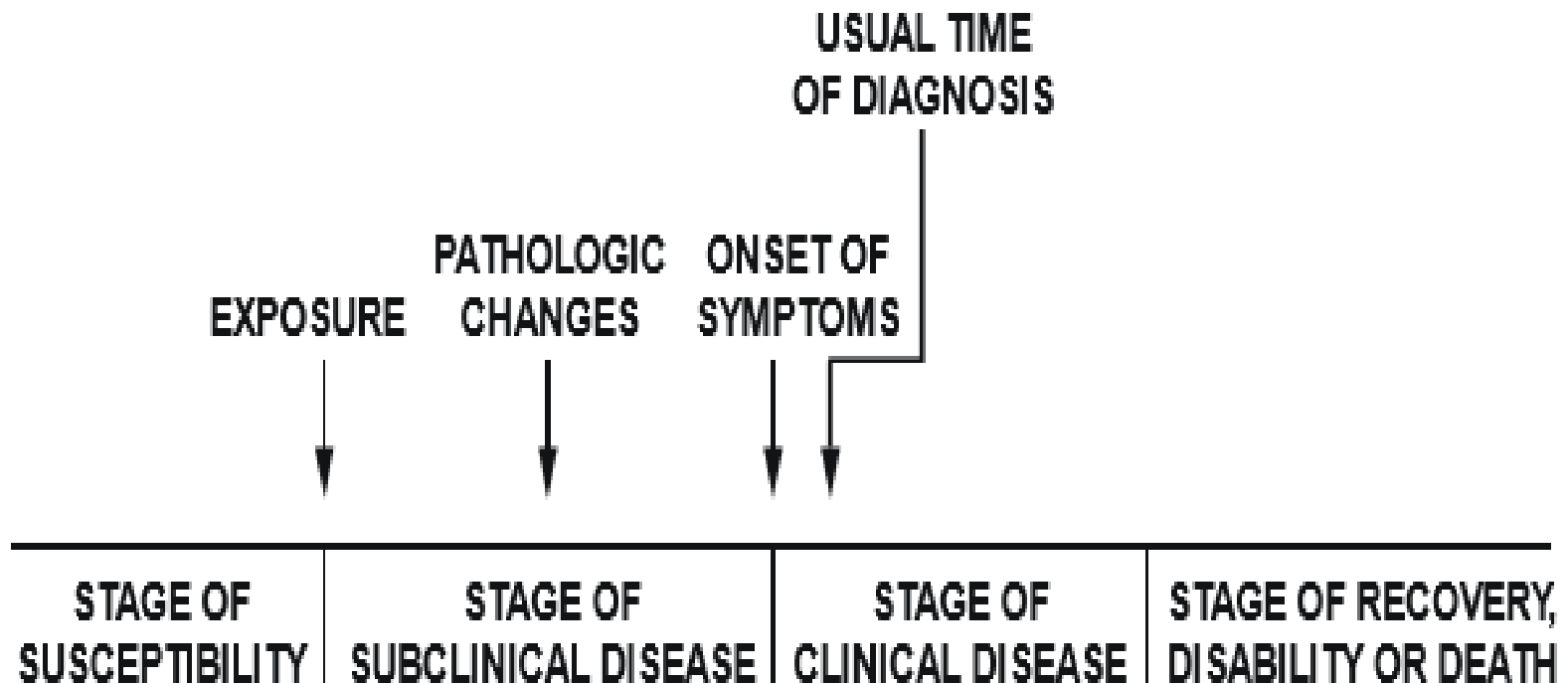
Natural History of Diseases

Natural history of disease

- o Refers a disease process in an individual over time, in the absence of intervention.
- o Begins with exposure to or accumulation of factors capable of causing disease.
- o Without medical intervention, the process ends with recovery, disability, or death.
- o Most disease has a characteristic natural history, although the time frame and specific manifestations of disease may vary from individual to individual.

Stages in the natural history of disease

Natural history of disease



Natural history disease

- The natural history of infectiousness includes:
 - ✓ *Prepatent period: the time interval from infection to becoming infectious (shedding of the agent).*
 - ✓ *Infectious period: the time during which an infected host could infect another host or vector.*
 - ✓ *Incubation period: the time from infection to symptomatic disease.*

Natural History...

- Natural history begins with the appropriate exposure to or accumulation of factors sufficient to begin the disease process in a susceptible host.
 - For infectious disease, the exposure is usually a microorganism.
 - For cancers, the critical factors may require both cancer initiators , such as
 - asbestos fibers or components in tobacco smoke (for lung cancer),
 - cancer promoters , such as estrogens (for endometrial cancer).

Natural History...

- **Stage of susceptibility:** disease has not yet developed, but the ground work has been laid by the presence of factors that favor its occurrence.
 - E.g. Unvaccinated child is susceptible to measles
- **Stage of pre-symptomatic** (sub clinical disease): there are manifestations of the disease but pathologic changes have started to occur. The disease can only be detected through special tests since the signs and symptoms of the disease are not present.
 - E.g. detection of antibodies HIV in an apparently healthy person
 - Ova of intestinal parasite in the stool of apparently healthy child
- The pre-symptomatic stage may lead to the clinical stage, or may sometimes end in recovery without

Natural History...

- ***Clinical stages***: the person has developed signs and symptoms of the disease.
- The duration, severity and outcome differs with different disease.
- The outcome can be recovery, disability or death
 - E.g. common cold has a short and mild clinical stage and almost everyone recovers quickly
 - Polio has a severe clinical stage and many patients develop paralysis becoming disabled for the rest of their lives
 - Rabies has a relatively short but severe clinical stage and almost always results in death.

Natural History...

- ***Stage of disability or death:*** Some disease run their courses and then resolves completely either spontaneously or by treatment.
- The disease may result in a residual defect, leaving the person disabled for a short or longer duration.
 - E.g Trachoma may cause blindness
 - Meningitis may result in blindness or deafness
 - Meningitis may also result in death

Natural History...

- A period of subclinical or in-apparent pathologic changes follows exposure, ending with the onset of symptoms.
- For infectious diseases, this period is usually called the ***incubation period*** ;
- For chronic diseases, this period is usually called the ***latency period***.
 - This period may be as brief as seconds for hypersensitivity and toxic reactions to as long as decades for certain chronic diseases.
- For some disease it has a range
 - For hepatitis A, about 2 to 6 weeks.
 - For leukemia associated with exposure to the atomic bomb blast in Hiroshima, the range was 2 to 12 years with a peak at 6 to 7 years
 - Although disease is inapparent during the incubation

Natural History...

- The onset of symptoms marks the transition from subclinical to clinical disease.
- Most diagnoses are made during the stage of clinical disease.
 - In some people, however, the disease process may never progress to clinically apparent illness.
 - In others, the disease process may result in a wide spectrum of clinical illness, ranging from mild to severe or fatal.
- Terms used to describe an infectious disease with various outcome
 - ***Infectivity*** :The proportion of exposed persons who become infected.
 - ***Pathogenicity***: The proportion of infected persons who develop clinical disease.

Natural History...

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

Natural History...

- The natural history and spectrum of disease presents challenges to the clinician and to the public health worker.
 - Cases diagnosed 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
 - persons with inapparent or undiagnosed infections may be able to transmit the disease to others.
 - persons who are infectious but have subclinical disease are called **carriers**.
- E.g. Persons with measles, hepatitis A,
 - become infectious a few days before the onset of symptoms.
- carriers may also be persons who appear to have recovered from their clinical illness,
 - E.g. chronic carriers of hepatitis B virus.

Level of prevention

- The major purpose in investigating the epidemiology of diseases is to learn how to prevent and control them.
- Disease prevention means to interrupt or slow the progression of disease.
- The concept of prevention is best defined in the context of levels, traditionally called
 - primary, secondary and tertiary prevention.
- A fourth level, called primordial prevention, was later added.

Determinants of Prevention

- Successful prevention depends upon:
 - ✓ A knowledge of causation,
 - ✓ Dynamics of transmission,
 - ✓ Identification of risk factors and risk groups,
 - ✓ Availability of prophylactic or early detection and treatment measures,
 - ✓ An organization for applying these measures to appropriate persons or groups, and

Types of prevention

- ✓ Primordial prevention
- ✓ **Primary Prevention**
- ✓ **Secondary Prevention**
- ✓ **Tertiary Prevention**

Primordial prevention

- It is the prevention of the emergence or development of risk factors in countries or population groups in which they have not yet appeared.
- Inhibit the emergence of risk factors in the form of environmental, economic, social, and behavioral conditions and cultural patterns of living.

Primordial prevention

- Many adult health problems (e.g. obesity, hypertension) have their early origins in childhood, because this is the time when lifestyles are formed (such as, smoking, eating patterns, physical exercise).
- In primordial prevention, efforts are directed towards discouraging children from adopting harmful lifestyles
- The main intervention in primordial prevention is through individual and mass education

Primary prevention

1. Primary prevention

- The main objective is promoting health, preventing exposure and preventing disease.
 - Usually it is on healthy person
 - It keeps the disease from becoming established by eliminating causes of disease or increasing resistance to disease
- Primary prevention has three components
- 1.1. Health promotion
 - 1.2. Prevention of exposure
 - 1.3. Prevention of disease

Primary prevention

1.1. Health promotion

- Includes general non specific intervention that enhance health and the body's ability to resist disease.
 - E.g. Improvement of socio-economic status, provision of adequate food, housing, clothing, and education

1.2. Prevention of exposure

- It is avoidance of factors which may cause disease if an individual is exposed to them
 - E.g. provision of safe and adequate water, proper excreta disposal, and vector control

Primary prevention

1.3. Prevention of disease

- Prevention of disease development after the individual has become exposed to the disease causing factor.
 - E.g. Immunization because it acts after exposure has taken place
- Immunization does not prevent an infectious agent from invading the immunized host, but does prevent it from establishing an infection.
- Measles vaccine will not prevent the virus from entering to the body but it prevents the development of infection/disease

Primary prevention

Achieved by

Health promotion

- Health education
- Environmental modifications
- Nutritional interventions

↓
Life style and behavioral changes

Specific protection

- Immunization and prophylaxis
- chemoprophylaxis
- Use of specific nutrients or supplementations
- Protection against occupational hazards
- Safety of drugs and foods

10/26/2013

Secondary prevention

- The objective is to stop or slow the progression of disease so as to prevent or limit permanent damage.
- It can be achieved through detecting people who already have the disease as early as possible and treat them.
- It is carried out on diseased individual before the person is permanently damaged
 - E.g. prevention of blindness from trachoma
 - Early detection and treatment of breast cancer to prevent its progression to the invasive stage, which

Secondary prevention

- Secondary prevention attempts to arrest the disease process, restore health by seeking out unrecognized disease and treating it before irreversible pathological changes take place, and reverse communicability of infectious diseases.
- It thus protects others in the community from acquiring the infection and thus provide at once secondary prevention for the infected ones and primary prevention for their potential contacts.

Tertiary prevention

- It is targeted towards people with permanent damage or disability.
- It is defined as “all the measures available to reduce or limit [impairments](#) and [disabilities](#), and to promote the patients’ adjustment to irremediable conditions.”
- Intervention that should be accomplished in the stage of tertiary prevention are [disability limitation](#), and [rehabilitation](#).

Tertiary prevention

- It has two objectives
 - Treatment to prevent further disability or death
 - To limit the physical, psychological, social and financial impact of disability, thereby improving the quality of life. Rehabilitation is a means
 - *E.g. Blindness due to vitamin A deficiency rehabilitation help to learn to do gainful work and be economically self supporting.*

summary Levels of Prevention

Stage of disease	Level of prevention	Type of response
Pre-disease	Primary Prevention	Health promotion and Specific protection
Latent Disease	Secondary prevention	Pre-symptomatic Diagnosis and treatment
Symptomatic Disease	Tertiary prevention	•Disability limitation for early symptomatic disease •Rehabilitation for late Symptomatic disease

The infectious disease cycle

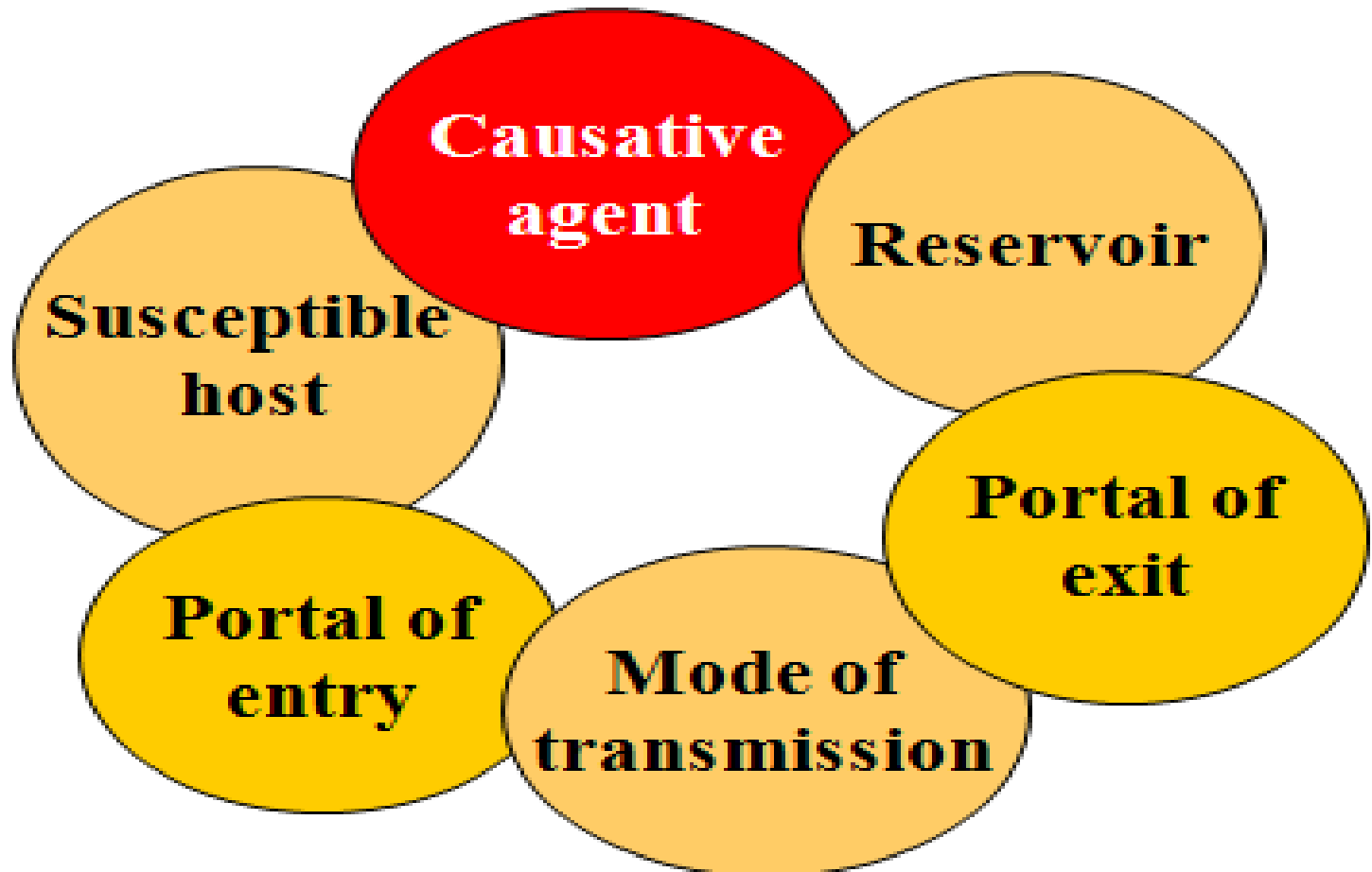
- o **Infection:** implies that the agent has achieved entry and begun to multiply in the host and leads to disease.
- o This is sometimes called the *chain of infection, or transmission cycle*.
- o For infection to occur a chain of events must take place.

Cont`d

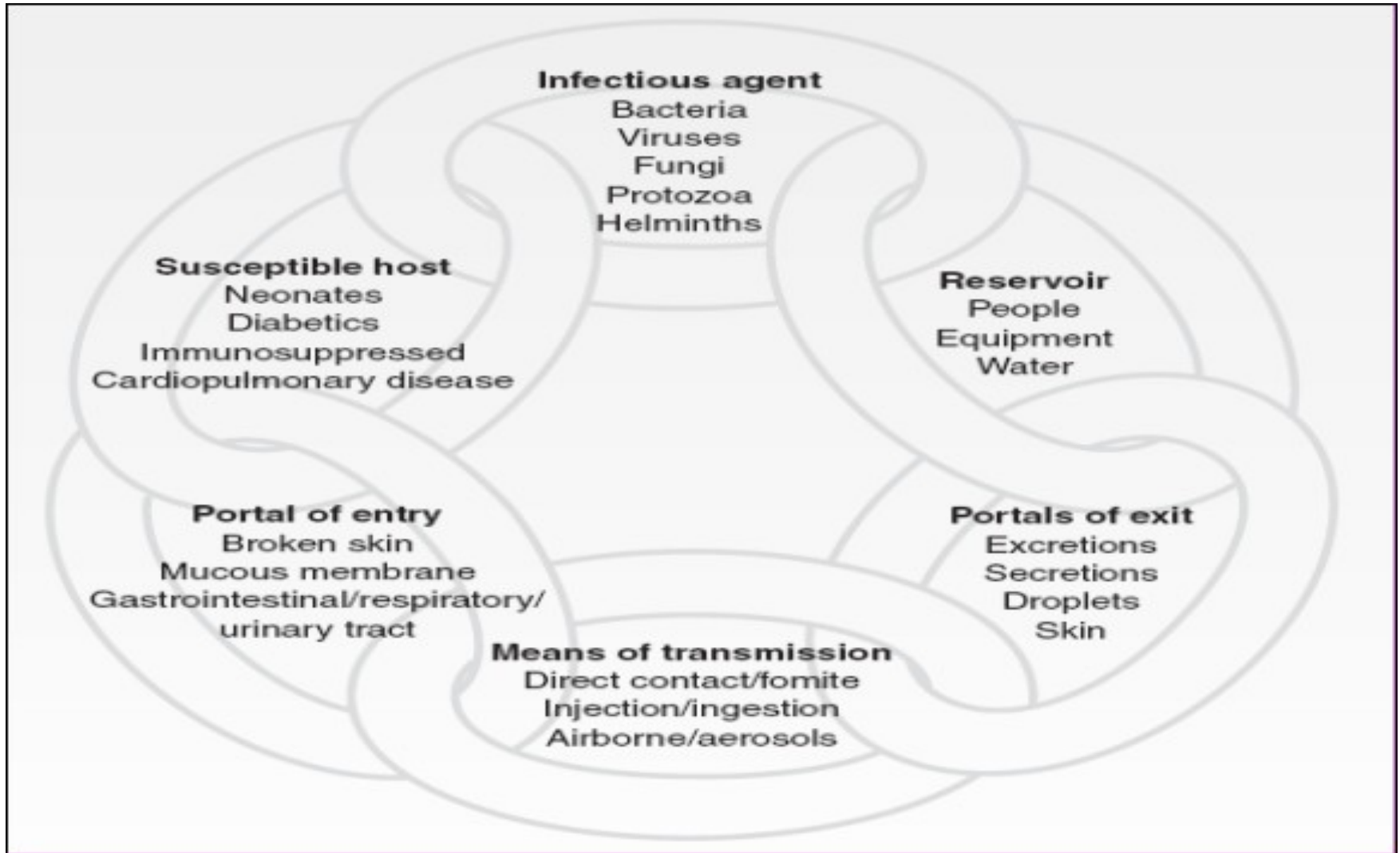
The infectious process of a specific disease can be described by six factors of diseases transmission cycle.

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

model of infectious diseases cycle



Chain of infection



1. Agent:

An infectious micro-organism

- bacteria**
- viruses**
- fungus**
- protozoas**

Cont`d

- The agent causes infection and disease depending on its basic inherent characters.
 - Infectiousness
 - Pathogenecity
 - Virulence

Infectiousness (infectivity) is measured by infection rate (IR)

$$\mathbf{I.R} = \frac{\text{no. of persons infected}}{\text{no. of susceptible and exposed}} \times 100$$

no. of susceptible and exposed

Cont`d

Pathogenecity:

- is the ability of an infectious agent to cause disease after infection.
- measured by sub-clinical to clinical ratio or can also be measured by proportion of clinical cases among infected.

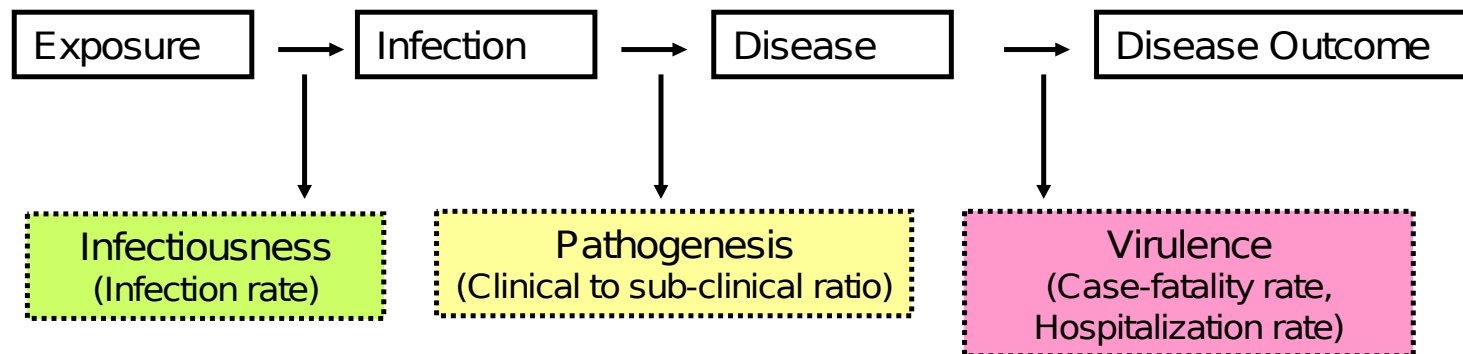
Cont'd

Virulence

- is the ability of an infectious agent to cause severe clinical disease.
- Measured by :

$$\text{Case Fatality Rate} = \frac{\text{No. of fatal cases}}{\text{Total number of cases}} \times 100$$

$$\text{Hospitalization Rate} = \frac{\text{No. of hospitalized cases}}{\text{Total no. of cases}} \times 100$$



Cont`d

2. Reservoir:

The habitat of an infectious agent where it normally lives, grows and multiplies.

- Eg dog for rabies, - Cattle for anthrax

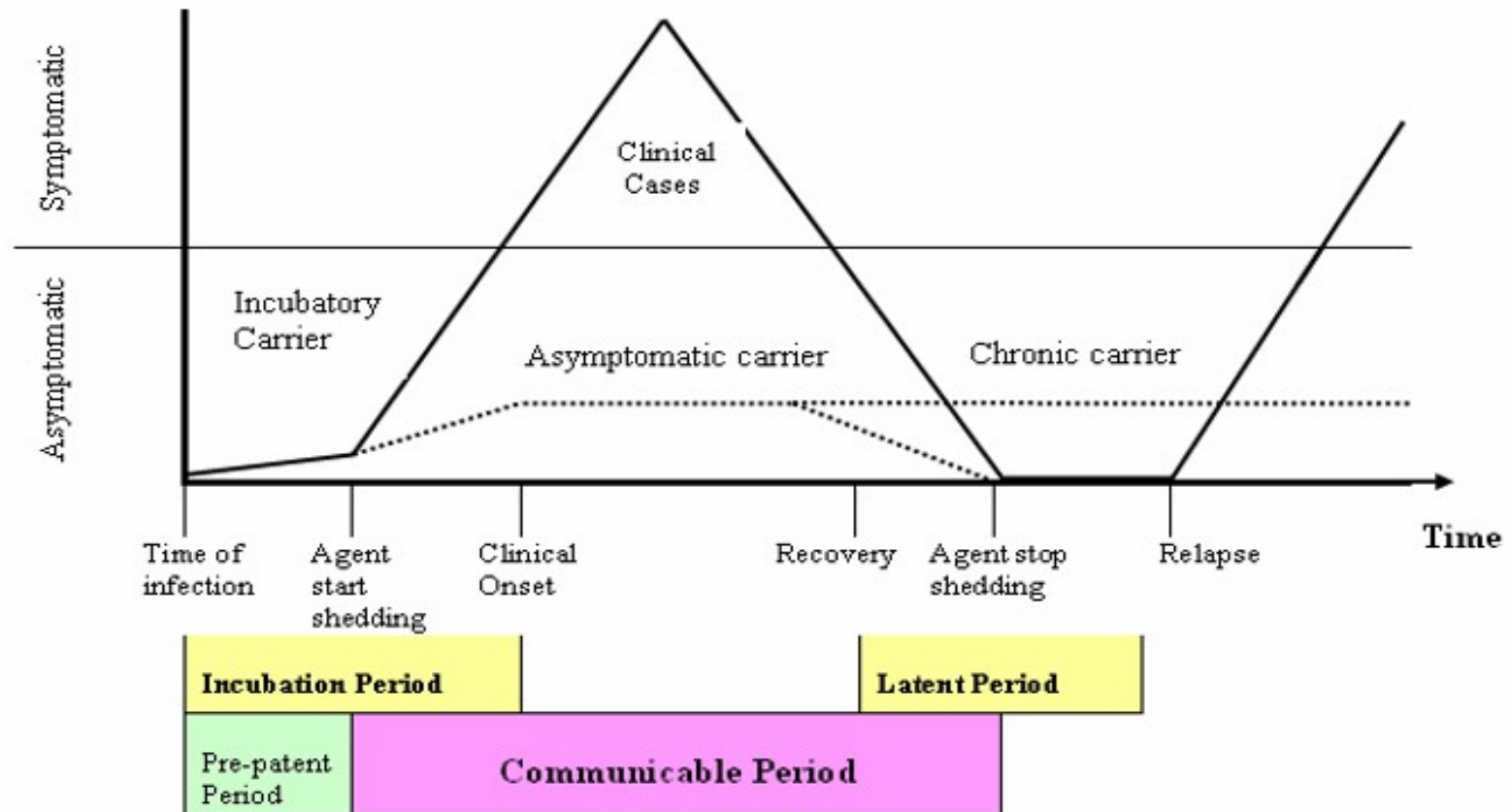
- **Carrier:** A person without apparent disease who is capable of transmitting the agent to others.

- *Asymptomatic carrier*: transmitting infection without ever showing signs of the disease.
e.g polio, ameobiasis

Cont`d

- *Incubatory carrier*: transmitting infection by shedding the agent before the onset of clinical manifestations.
e.g measles
- *Convalescent carrier*: Transmitting infection after the time of recovery from the disease
e.g typhoid fever
- *Chronic carrier*: Shed the agent for a long period of time, or even indefinitely.
e.g viral hepatitis, typhoid fever

Time course of a disease in relation to its clinical expression and communicability



Cont'd

1- Prepatent period

- Prepatent period is the time interval between infection and the time of first shedding of the agent by the host as measured by the point at which the infection can first be detected.
- The agent may be shed by any of the portals of exit: example malaria through the blood.

Cont`d

- For some diseases the time when the agent can first be detected and the time of the first shading do have difference, i.e the detection might not be possible at the beginning of the shading.
- This lag is called the window period, e.g. the window period of HIV.
- Generally a patient is harmless to the community during the prepatent period except in the case of window period.

Cont`d

2- Incubation period

- Incubation period is the time interval between infection and first clinical manifestation of disease
- Knowledge of the incubation period of infectious diseases helps in clinical diagnosis of the diseases, but more importantly it is utilized to uncover the source of outbreaks in epidemic investigation.

Cont'd

3- Communicable period

- Communicable period is the period during which an infected host can transmit the infection to others.
- Communicable period can be measured by the time interval during which the agent is shed by the host.
- It extends from the point of the first shading up to the last shading of the agent by the host.

Cont`d

4- Latent period

- Latent period is the time interval between recovery and the occurrence of a relapse or recrudescence in clinical disease.

example: Typhus and malaria have latent period b/c they relapse after a time.

3. 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 (including the placenta).

4. Modes of Transmission

- **The transfer of an infectious agent from an infected host (reservoir) to a susceptible host.**
- **Direct transmission: Immediate transfer of the agent from a reservoir to a susceptible host.**
- **Indirect transmission: Transmission of an infectious agent to a susceptible host through the aid of a vehicle, a vector or suspended air particles.**

Cont`d

- **Direct transmission**

- ☐ Touching
- ☐ Kissing
- ☐ Biting
- ☐ Direct projection
- ☐ Blood transfusion

- **Indirect transmission**

- ☐ Airborne
- ☐ Vehicle-borne
- ☐ Vector-borne
- ☐ Non-vector
intermediate host
- ☐ Parenteral injections

Cont`d

Direct transmission

1.1 *Direct contact*: The 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, rabies, gonorrhea

1.2 *Direct projection*: projection of saliva droplets by coughing, sneezing, singing, spitting or talking.

Example: common cold

1.3 *Transplacental*: Transmission from mother to fetus. Example: syphilis

Cont`d

2. Indirect transmission

2.1 Vehicle-borne:

- A vehicle is any non-living substance or object by which an infectious agent can be transported and introduced in to a host through a suitable portal of entry.
- Transmission occurs through indirect contact with inanimate objects (fomites): bedding, toys, or surgical instruments; as well as through contaminated food, water, IV fluids etc.

Cont`d

2.2 Vector-borne:

A vector is an organism (usually an arthropod) which transports an infectious agent to a susceptible host or to a suitable vehicle.

Biological vector:

- A period of multiplication and/or development of the agent in the vector is required before transmission to the host can occur (**extrinsic incubation period**).
- Transmission occurs while the vector is feeding on its host.

Cont`d

Mechanical vector:

- agent is directly infective to the host, without having to go through a period of multiplication or development.
- agent is transported (carried) on the leg or mouth parts of the vector, or passes through its gastrointestinal tract and is excreted or regurgitated onto the host or vehicle.
- Introduction of the agent into the host is either:
 - by vector-host contact (e.g- Trachoma by flies),
 - through contamination of a vehicle

Cont`d

Airborne: which may occur by dust or droplet nuclei (dried residue of aerosols)

Example: Tuberculosis

Non vector intermediate host: hosts not playing an active role in transporting the agent to humans.

Example: Aquatic snails in the transmission of schistosomiasis.

5. Portal of entry

Is the site where an infectious agent enters a susceptible host.

The Mucosa:

- Nasal
- Conjunctival
- Respiratory
- Vaginal -
- Urethral

Injury site: Tetanus

Skin: Hook worm infection (Ancylostomiasis)

6. Susceptible host

- The susceptible human host is the final link in the infectious process.
- Host susceptibility can be seen at the *individual* level and at the *community* level.
- ***At the individual level:*** The state of the host at any given time is the interaction of genetic endowment with the environment over the entire life span.

Cont`d

Examples:

- *Genetic factors*: sex, blood type, ethnicity etc.
- *Environmental factors*: immunity acquired as a result of past infection
- ***At the community level***: Host resistance at the community (population) level is called ***herd immunity***.

Basic measurement in epidemiology

Measure of frequency

- Count
 - Ratio
 - Proportion
 - Rate
-
- ▶ In epidemiology, many **nominal** variables have only two possible categories: e.g. alive or dead; case or control; exposed or unexposed. Such variables are called **dichotomous** variables.
 - ▶ The frequency measures we use with dichotomous variables are ratios, proportions, and rates.

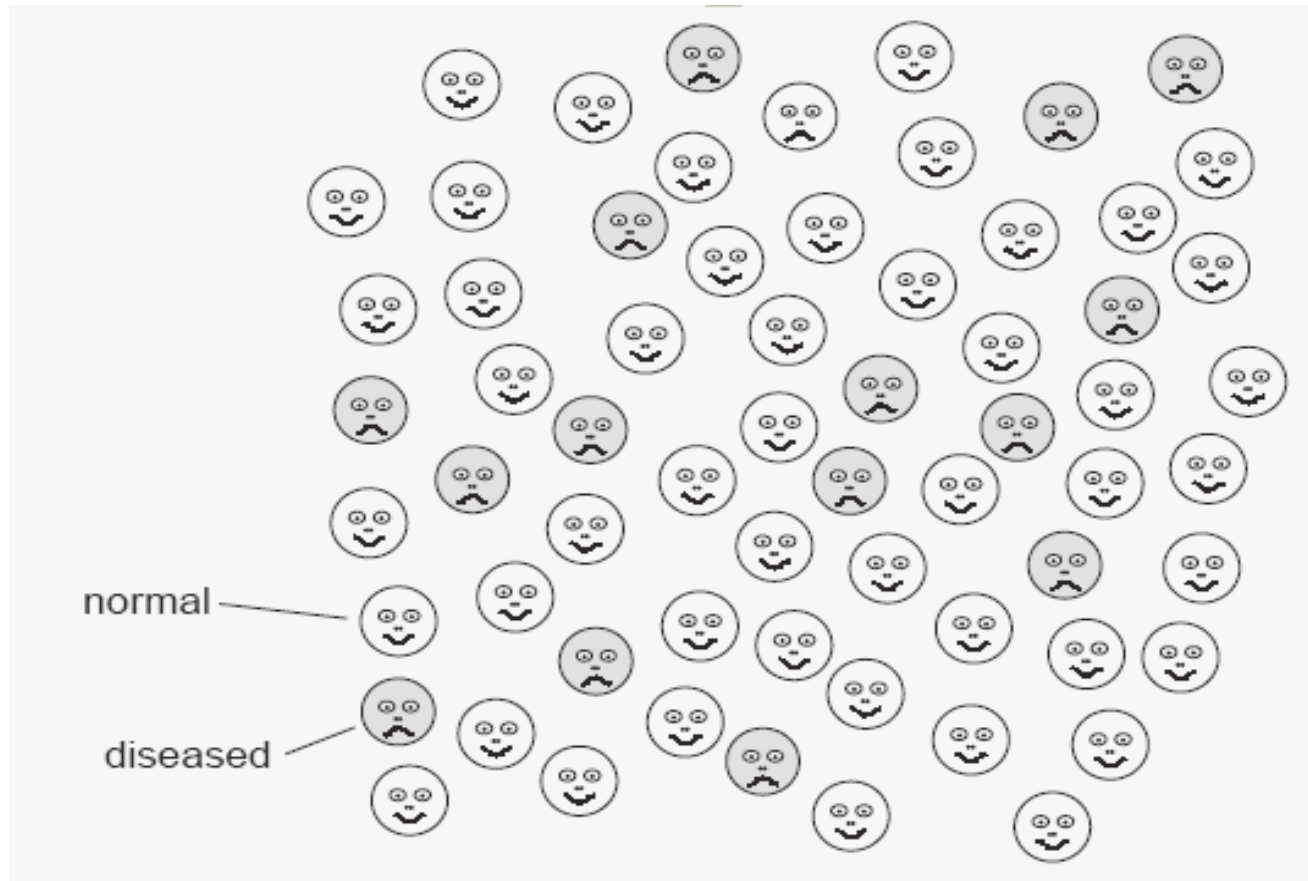
Counts

- ▶ The number of persons in the group studied who have particular disease or particular characteristic

E.g. number of student

- ◆ Common descriptive measure
- ◆ First step in calculating rates
- ◆ Essential for service delivery, planning
- ◆ It is simple counting of cases of a disease

Simple count



Ratio

A **ratio** is the relative size of two quantities

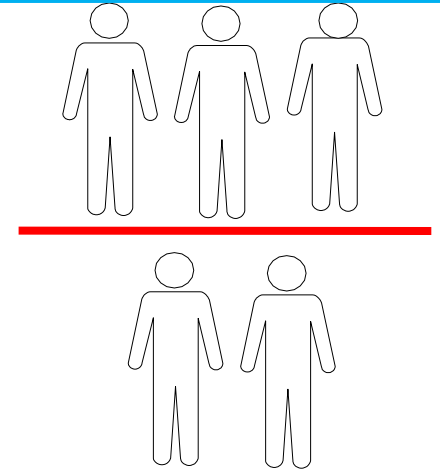
- ▶ Quantifies magnitude of some event in relation to the other

E.g. sex ratio

- ▶ No specific relationship is necessary between the numerator and denominator
- ▶ (numerator **NOT necessarily included** in the denominator)

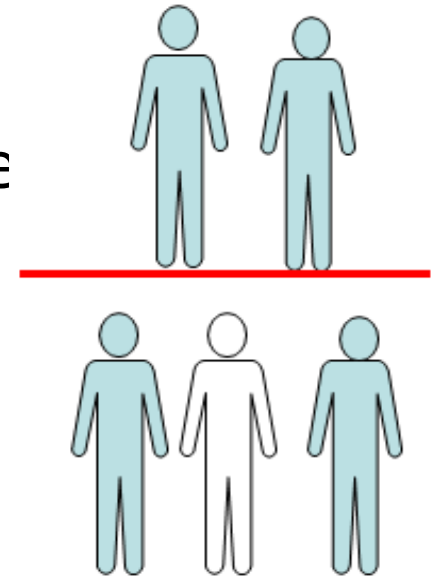
- o # beds per doctor
 - 120 beds/10 doctors
 - 120/10 : 10/10
 - 12 beds for a doctor

- o Odds ratio
- o Rate ratio
- o Maternal mortality rate



Proportion

- It is comparison of a part to the whole population
- Numerator **MUST BE INCLUDED** in the denominator
- Its result ranges between 0 and 1 or (0-100%)
- Percentage = Proportion x 100



is one of the most common ways of expressing proportions

- Eg. Population 3500 women
 6500 men

Proportion of men: $6500/(3500+6500)=0.65$ or

Rate

Measures the **occurrence of an event in a population over time**

- ▶ It can be seen as a **proportion with a time dimension**
- ▶ Rates are often proportions

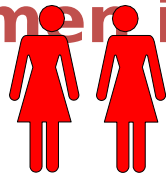
$$\text{Rate} = \frac{\text{number of cases or events occurring during a given time period}}{\text{population at risk during the same time period}} \times 10^n$$

Notice t

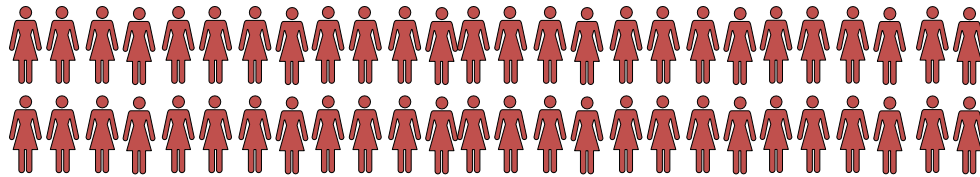
- The persons in the denominator must reflect the population from which the cases in the numerator arose.
- The counts in the numerator and denominator should cover the same time period.
- In theory, the persons in the denominator must be “at risk” for the event, that is, it should have been possible for them to experience the event.

Cervical cancer cases in menopausal women in 2019

Total number of menopausal women in 2019



Observed in 2006



Total population in 2006

$$\frac{2}{100} = 0.02 / \text{year}$$

- Rate may be expressed in any power of 10 (10^0 , 10^1 , 10^2 , 10^3 , 10^n)
- 100, 1,000, 10,000, 100,000

Measures of disease occurrence

Two types of measures :

1. Prevalence

Which measures a population's disease status
(two forms)

1. Point Prevalence
2. Period prevalence

2. Incidence

Assesses frequency of disease onset
(two forms)

2. Cumulative incidence/ incidence proportion
3. Incidence density or incidence rate

Prevalence

**Number of cases of a disease at a
specific time**

Mid-year population at the specified time

- **It is proportion of a population affected by a disease at a given time.**
- **It is expressed as a percentage, per thousand, per hundred thousand**

HIV/AIDS in X city in 1999:

Population	210,000
Cases	3,200
Prevalence	1.5%

Point Prevalence

- It is proportion of a population that is affected by disease at a given point in time
- The amount of disease in a population usually changes constantly
- Thus, may not be useful for assessment of diseases with short generation period

Period prevalence

- If we want to know how much disease is present over a longer period of time, **period prevalence** would be preferred.

Number of cases of a disease at a

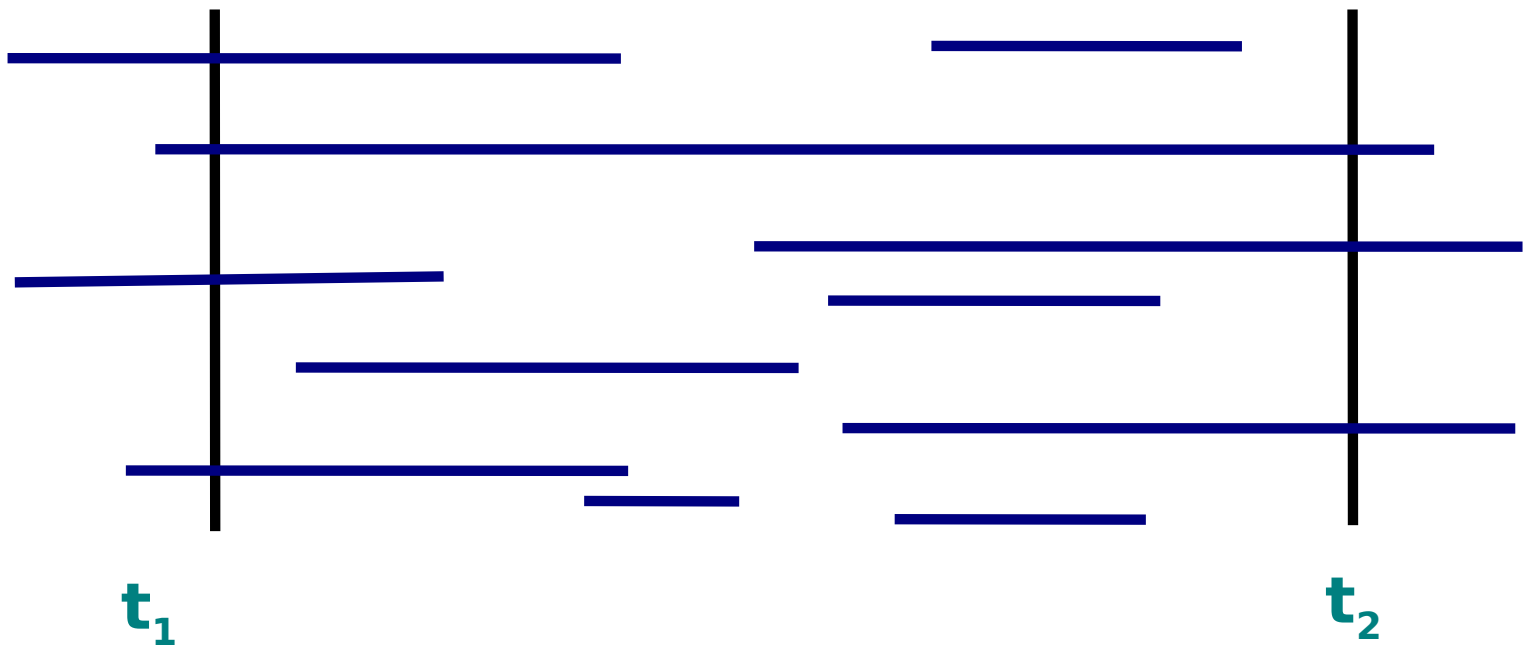
specific time

Mid-year population at the specified
time

$$\text{Mid-year population} = \frac{\text{total population at starting} + \text{total population at the end}}{2}$$

Example

A total of 100 people were at risk of disease x, which has no life time immunity.



What is the prevalence of disease X during time t_1 ?

Prevalence question

Interview

question

Do you currently have asthma?

Have you had asthma in the last 10 years?

Have you ever had asthma?

Type of

measure

~~Point prevalence~~

Period prevalence

Lifetime prevalence

2. Incidence

- The number of new events of a disease in a defined population at risk within a specified period of time.

Number of NEW cases of disease during a specific
~~period~~

Population at risk during such period

- Two forms,
 1. Cumulative incidence
 2. Incidence density

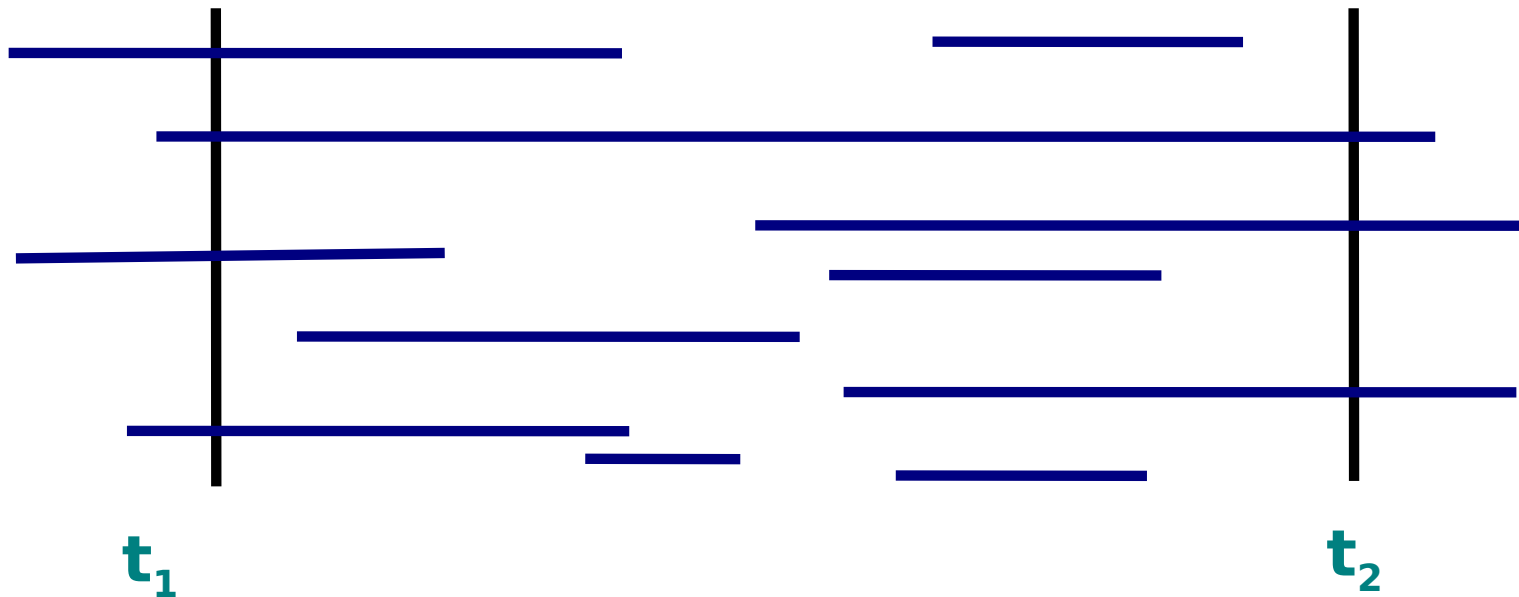
a. Cumulative Incidence

It assumes that the entire population is at risk and is followed up for specified time of period



Example

A total of 100 people were at risk of disease x, which has no life time immunity.



What is the cumulative incidence of disease X during time between t_1 and t_2 ?

b. Incidence density (rate)

Number of **NEW** cases of disease during a
~~period~~

Total person-time of observation

Rate

Instantaneous concept of rate (**=
speed**)

Denominator:

- the sum of each individual's time
at risk (or time free of a disease) is
counted

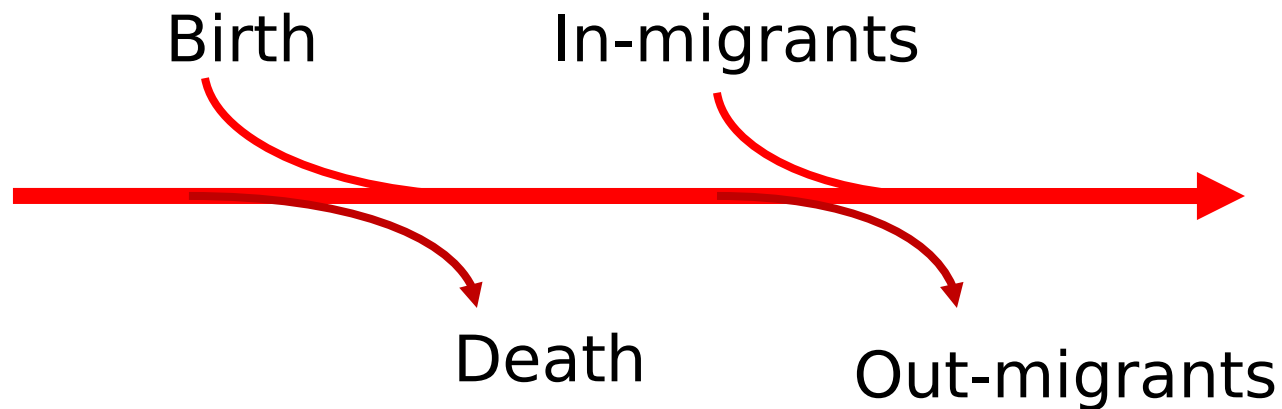
Incidence (density) rate

- Incidence rate must take into account
 - Number of individuals who become ill in a population
 - Time periods experienced by member of the population during follow up.

Person- time

- It is sum of length of time period passed free of illness (at risk) by each individual member of study
- It accounts for the amount of exposure time of members
- It is a good measure in a dynamic cohort
- Dynamic cohort is a cohort of people leaving and entering a study at different time of period

Dynamic (open) cohort study

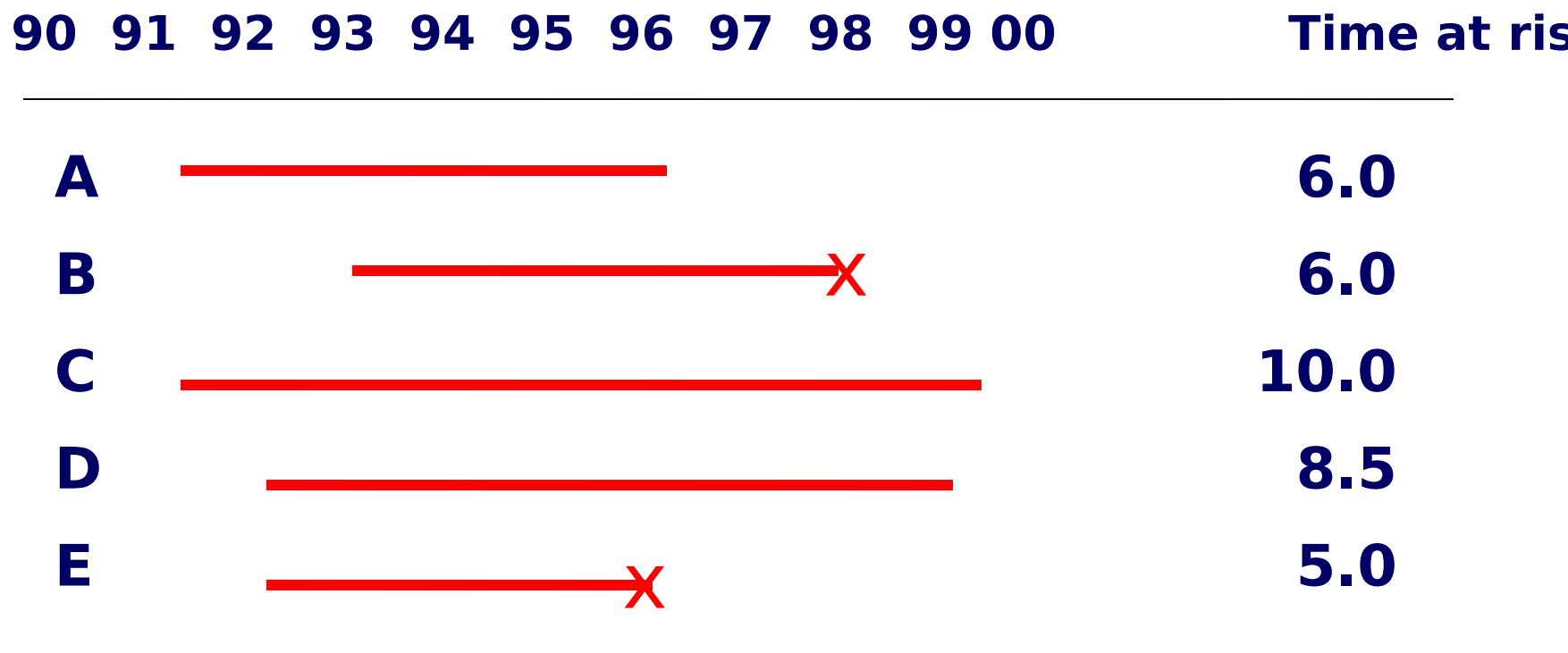


g. Butajira Rural Health Program

Cont`d

What is person-time for?

1. 100 people followed for 1 year each
2. 10 people followed for 10 years each
3. 50 people followed for 1 year each plus 25 people followed for 2 years each
4. Time unit=month, year, day; person-time=person-year, person-month,



Total years at risk	35.5
----------------------------	-------------

-- time followed
x disease onset

$$\begin{aligned}
 \text{ID} &= 2 / 35.5 \text{ person-years} \\
 &= 0.056 \text{ person-year}
 \end{aligned}$$

Comparing Incidence and Prevalence

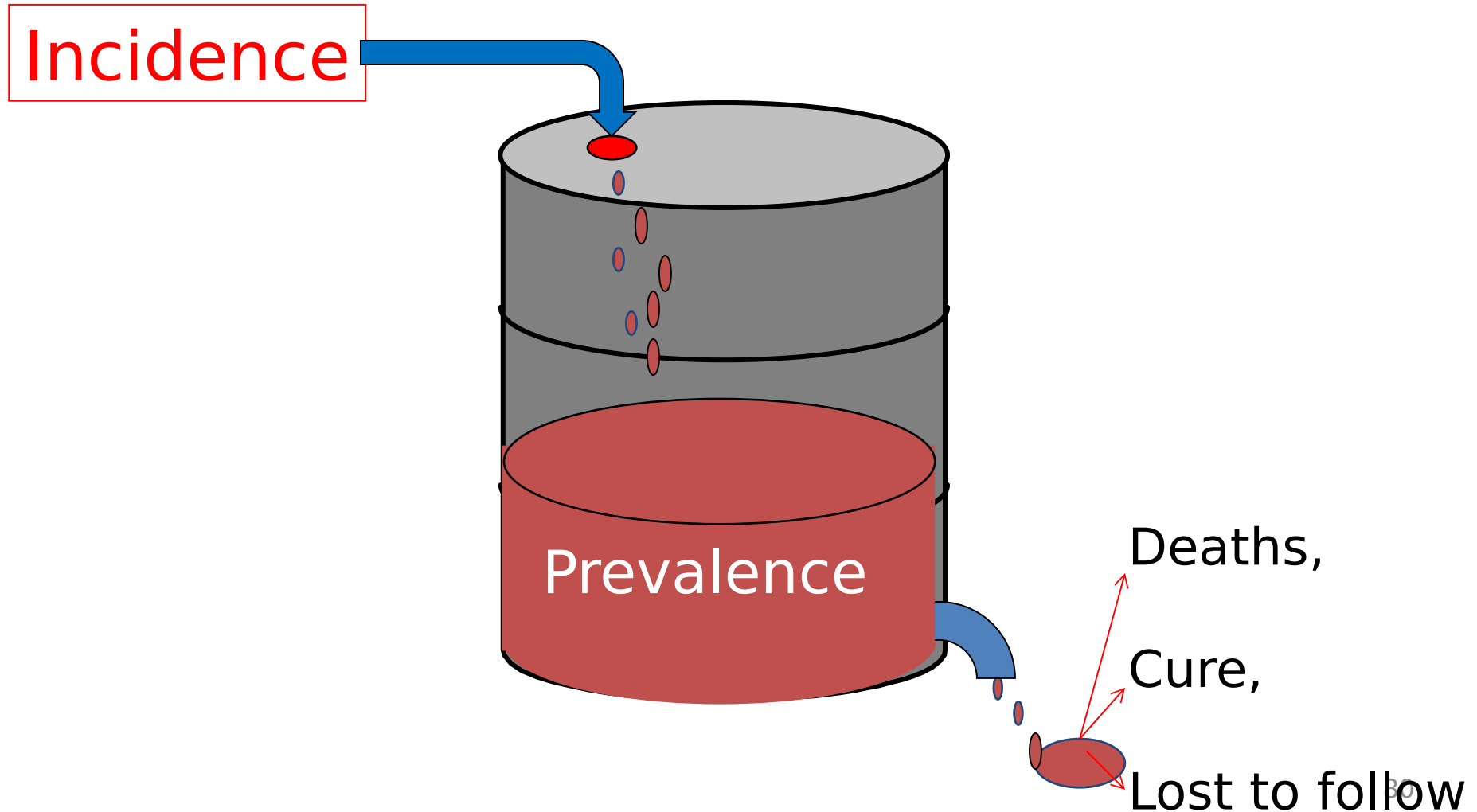
Incidence

- New cases or events over period of time
- Useful to study factors causing disease,
- Useful in “risk” estimation

Prevalence

- All cases at point/period of time
- Useful for measuring size of problem
- For planning

Relationship between Incidence, Prevalence and Disease Duration



Factors Affecting Prevalence

Increased by:

Longer duration of the disease

Prolongation of life of patients without cure

Increase in new cases (increase in incidence)

In-migration of cases

Out-migration of healthy people

In-migration of susceptible people

Improved diagnostic facilities (better reporting)

Decreased by:

Shorter duration of disease

High case-fatality rate from disease

Decrease in new cases (decrease in incidence)

In-migration of healthy people

Out-migration of cases

Improved cure rate of cases

Prevalence

- Probability of already having a disease
- Numerator counts all cases of a disease, both existing and new
- Depends on duration of disease (long duration increases prevalence)
- Estimates burden of disease and needs for health care resources

Incidence

- Probability of getting the disease in a given time period
- Requires follow-up of individuals to identify new cases
- Does not depend on duration of the disease
- Used when studying causes of disease and spread of disease

Special Types of Incidence:

Attack Rate

- ✓ Narrowly defined population
- ✓ Observed for a limited time (e.g. epidemic).
- Usually expressed as a percent.

(primary) Attack rate =

***Number of new cases among the
population during the period***

x 100

***Population at risk at the
beginning of the period***

Attack Rate:

Example

Of 75 persons who attended a church picnic, 46 subsequently developed gastroenteritis.

a) Calculate the attack rate of gastroenteritis :

x = Cases of gastroenteritis occurring within the incubation period for gastroenteritis among persons who attended the picnic = 46

y = Number of persons at the picnic = 75

$AR = 46/75 \times 100\%$

Cont`d

Secondary attack rate: is an important measure of spread of disease among contacts of an index case.

- It is often defined for exposure to an infective within some small population unit, such as

$$\text{SAR} = \frac{\text{Number of persons exposed (have contact with a known case) who develop disease}}{\text{Total number of susceptible exposed person}} \times 10^n$$

Cont`d

- **NB:** the index cases are not included in both the numerator and denominator.

In other ways,

Secondary attack rate = Total number of cases - Index cases

No. of susceptible - Index cases

Cont`d

- The data required for estimating secondary attack rate are:
 - the time of onset of disease for each case in the household;
 - knowledge of who is susceptible;
 - estimates/assumptions about minimum and maximum incubation periods;
 - the latent period; and the maximum time that a person remains infectious; sometimes it can be assumed that the onset of symptoms coincides

- ▶ Incidence measures rapidity with which newly diagnosed patients develop over time.
- ▶ Most common way of measuring and comparing the frequency of disease in populations.

Uses of Incidence

- For etiologic studies of both acute and chronic diseases.
- Direct indicator of risk
- Helps to generate hypothesis

Standardization

Crude, specific & standardized (adjusted) rates

- Crude rates
 - total population (e.g. crude birth rate)
- Specific rates
 - population subgroups (e.g. age-group specific death rate)
- Standardized rates
 - Rates after adjusting for a specific grouping
(age, sex, etc.)

Crude rates

- Summary rates
- Based on numbers of events
 - e.g. births, deaths
- ◆ Crude death rate is influenced by:-
 - Individual probability of dying
 - Population age distribution

Specific rates

- Uses
 - Detailed understanding of disease occurrence in different population subsets.
 - It could show detailed rates of specific group
(Age, sex, ethnicity)
- Disadvantages
 - Difficult to compute/ interpret

Standardized (adjusted) rates

- Crude rates
 - Comparison is suitable only when populations are similar in all respects
- Adjustment or standardization
 - Produces summary rates adjusted (controlled) for (age, sex, etc) difference
 - Standardization makes the population comparison

Standardization:

- The process by which you derive a summary figure to compare health outcomes of groups
- The process can be used for mortality and morbidity data
- Two methods
 - Direct
 - Indirect

1. Direct Adjustment of Rates

◆ It requires

1. a **standard population** to which the estimated specific rates are applied
2. **Specific rates** of event for the study population

Standard Population



1. US 1940 population
2. US 2000 population
3. European standard population
4. WHO world population

**5. One of the study
populations**

6. Sum of the study populations

Examples

Standard Population formation

- Comparing the death rate among the 10 regional states in Ethiopia,
 - The national population census of Ethiopia may be used as a standard population
 - or
 - It is also possible to use population of a single state as a standard population

Direct Standardization

Geographic area		Age group			
		15-44	45-64	65+	Total
AAA	Population	10	20	70	100
	Cases	1	5	35	41
	Prevalence	0.10	0.25	0.50	0.41
	Adjusted	41/100			0.41
BBB	Population	30	40	30	100
	Observed Cases	5	18	18	41
	Prevalence	0.17	0.45	0.60	0.41
	Expected cases	$0.17 \times 10 = 1.7$	$.45 \times 20 = 9$	$.60 \times 70 = 42$	53
	Adjusted P	53/100			0.53
DDD	Population	70	20	10	100
	Observed Cases	21	12	8	41
	Prevalence	0.30	0.60	0.80	0.41
	Expected case	$0.30 \times 10 = 3$	$0.60 \times 20 = 12$	$0.80 \times 70 = 56$	71
	Adjusted prevalence	71/100			0.71

Population living in geographic area AAA is used as reference population

Direct Method

Characteristics	Geographic Area		
	AAA	BBB	DDD
Observed cases	41	41	41
Observed prevalence	0.41	0.41	0.41
Adjusted prevalence	0.41	0.53	0.71
SRR (%) Standardized Rate Ratio	100	129	173

Comparisons are performed using the geographic area AAA population as standard (reference) population.

$$\text{SRR (\%)} = \frac{\text{Adjusted prevalence}}{\text{Observed prevalence}} \times 100$$

2. Indirect Standardization

Indirect method requires

- **Age structure** of the sample study population
- **Total cases (death) in the sample population**
- **Age-specific event (death) rates for a standard population**
- **Summary figure is a**

STANDARDIZED MORTALITY RATIO (SMR)

$$\text{SMR} = \frac{\text{Observed}}{\text{Expected}}$$

Indirect standardization

Geographic area		Age group			
		15-44	45-64	65+	Total
AAA	Population	10	20	70	100
	Cases	1	5	35	41
	Prevalence	0.10	0.25	0.50	0.41
BBB	Population	30	40	30	100
	Observed Cases				41
	Expected Cases	$(0.10 \times 30) + (0.25 \times 40) + (0.50 \times 30)$			28
DDD	Population	70	20	10	100
	Cases				41
		$(0.10 \times 70) + (0.25 \times 20) + (0.50 \times 10)$			17

Indirect Method

Characteristics	Exposure		
	Low	Medium	High
Observed cases	41	41	41
Observed prevalence	0.41	0.41	0.41
Expected cases	41	28	17
SMR (%) Standardized Mortality Ratio	100	146	241

Comparisons are performed using the low exposure group prevalence (rate) as standard.

$$\text{SMR} = \frac{\text{Observed}}{\text{Expected}} \times 100$$

SMR

- $SMR = 100$
 - Rates are similar to the standard population
- $SMR < 100$
 - Fewer deaths occurred than expected (rates are lower than the standard)
- $SMR > 100$
 - More deaths occurred than expected (rates are higher than the standard)

Special types of Incidence

Type	Numerator	Denominator
Morbidity rate	# cases	Population at risk
Mortality rate	# deaths	Population at risk
Case-fatality rate	# deaths from a disease	Total cases of that disease
Attack rate	# cases during "epidemic" period	Population at risk

Attack Rate

Number of new cases of a specified disease
reported during an epidemic period of time

Population at risk during the same time interval

Secondary Attack Rate

Number of new cases of a specified disease among
contacts of known cases

Size of contact population at risk

Mortality measures

When the event under study is death rather than the occurrence of disease, we usually use the term **mortality (rate) rather than **cumulative incidence**.**

Measures of mortality are used to quantify the occurrence of deaths in a defined population during a specified period. Some of the measures include:

a) **Crude Death Rate** = $\frac{\text{Total number of deaths in a year}}{\text{Average (or midyear) population}} \times 1000$

b) **Age specific Mortality Rate** = $\frac{\text{No. of deaths in a specific age in a year}}{\text{Average (midyear) population of the specific age group}} \times 1000$

c) **Sex specific Mortality Rate** = $\frac{\text{No. of deaths in a specific sex in a year}}{\text{Average (midyear) population of the specific sex}} \times 1000$

Neonatal Mortality Rate

$$= \frac{\text{No. of deaths of children less than 4 weeks old in a year}}{\text{No. of live births in the same year}} \times 1000$$

Infant Mortality Rate (IMR)

$$= \frac{\text{No. of deaths of children less than 1 year old in a year}}{\text{No. of live births in the same year}} \times 1000$$

Maternal Mortality ratio

$$\text{(MMR)} = \frac{\text{No. of women who died from pregnancy related causes in yr}}{\text{No. of live birth in the same year}} \times 100000$$

Some commonly used specific death rate:

- **Infant Mortality Rate**: the number of deaths of infants up to the age of one year per 1000 live-birth in a given year

$$IMR = \frac{\text{NO of deaths} < 1 \text{ yrs of age}}{\text{No of live birth during the same period}} \times 1000$$

- ***Use***

- To measure health status of the community
- To see availability and effective use of health care
 - E.g. Perinatal cares

- ***Neonatal Mortality Rate (NMR)***

$$\text{NMR} = \frac{\text{No death up to 28 days of age in calendar yr}}{\text{Number of live births in the same calendar year}} \times 1000$$

- **Use:** To see condition of the fetus and pre and post delivery

Child Mortality rate (CMR)

- Number of deaths at ages of 1-4 yrs in a given area per 1000 children in that age group at the mid point of the year concerned

$$\text{CMR} = \frac{\text{No of deaths of children 1-4 yrs of age during a yr} \times 1000}{\text{\# of children 1-4 yrs of age at the middle of the yr}}$$

- **Use:** Main environmental factor affecting the children:
 - Nutrition
 - Sanitation
 - Communicable Disease of children
 - Accident occurring in and around the home
- ***It is sensitive indicator socioeconomic development in a community***

Under Five Mortality Rate:

- Is the number of deaths of children under five years of age per 1000 children age under 5 years in a calendar year
- $$U5MR = \frac{\text{No of deaths U5 yrs of age in the given yr}}{\text{\# Of children U5 yrs of age in the middle of the yr}} \times 1000$$
- This rate combines both infant and child mortality rate

Maternal mortality rate

- is a ratio used to measure mortality associated with pregnancy

MMR= # of death of women from pregnancy related causes in a year
of live births in same year

- sensitive **indicator** of the health condition and the availability and utilisation of maternal health service especially prenatal care