What is *infectious disease epidemiology*?

<table>
<thead>
<tr>
<th>Epidemiology</th>
<th>Infectious disease epidemiology</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Deals with one population</td>
<td>- Two or more populations</td>
</tr>
<tr>
<td>- Risk case</td>
<td>- A case is a risk factor</td>
</tr>
<tr>
<td>- Identifies causes</td>
<td>- The cause often known</td>
</tr>
</tbody>
</table>
What is infectious disease epidemiology?

- Two or more populations
  - Humans
  - Infectious agents
    - Helminths, bacteria, fungi, protozoa, viruses, prions
  - Vectors
    - Mosquito (protozoa-malaria), snails (helminths-schistosomiasis)
    - Blackfly (microfilaria-onchocerciasis) – bacteria?
  - Animals
    - Dogs and sheep/goats – *Echinococcus*
    - Mice and ticks – *Borrelia*
What is *infectious disease epidemiology*?

A case is a risk factor …

- Infection in one person can be transmitted to others

The cause often known

- An infectious agent is a necessary cause

What is infectious disease epidemiology then used for?

- Identification of causes of new, emerging infections, e.g. HIV, vCJD, SARS
- Surveillance of infectious disease
- Identification of source of outbreaks
- Studies of routes of transmission and natural history of infections
- Identification of new interventions
Concepts Specific to Infectious Disease Epidemiology

- Attack rate, immunity, vector, transmission, carrier, subclinical disease, serial interval, index case, source, exposure, reservoir, incubation period, colonization, generations, susceptible, non-specific immunity, clone, resistance, repeat episodes...
• Infectious diseases
  – diseases involving an agent (bacterial, viral, parasitic) which is transmitted from infected to non-infected hosts
Definition of communicable diseases

• A communicable disease is an illness due to a specific infectious (biological) agent or its toxic products capable of being directly or indirectly transmitted from man to man, from animal to man, from animal to animal, or from the environment (through air, water, food, etc..) to man.
Infectious Disease

• Definitions
• Infectious diseases
  – Caused by an infectious agent
• Communicable diseases
  – Transmission – directly or indirectly – from an infected person
• Transmissible diseases
  – Transmission – through unnatural routes – from an infected person

• Note
• Infections are often subclinical – infections vs infectious diseases!
• Antonyms not well-defined
  – Non-communicable diseases – virus involved in pathogenesis of diabetes?
  – Chronic diseases – HIV?
Infectious diseases

- bacterial
  - salmonellosis, campylobacteriosis

- viral
  - polio, HIV, influenza

- parasitic
  - malaria, lymphatic filariasis
• Unlike non-infectious diseases, the occurrence of infectious disease events in a given host depends on:
  – occurrence of the disease in other members of the host population
  – length of time that infected hosts remain infectious
Infectious disease epidemiology

- centres around understanding the relationship between the host and infectious agent (or parasite) and the transmission of the infectious agent between hosts
Factors Influencing Disease Transmission

**Agent**
- Infectivity
- Pathogenicity
- Virulence
- Immunogenicity
- Antigenic stability
- Survival

**Host**
- Age
- Sex
- Genotype
- Behaviour
- Nutritional status
- Health status

**Environment**
- Weather
- Housing
- Geography
- Occupational setting
- Air quality
- Food
• **Terminology used to describe the various phases an individual goes through during the time course of an infectious disease process ...**
Incubation and Latent periods

• Incubation period: time from exposure to development of disease. In other words, the time interval between invasion by an infectious agent and the appearance of the first sign or symptom of the disease in question.

• Latent period: the period between exposure and the onset of infectiousness (this may be shorter or longer than the incubation period).
• Latent period
  – the time interval from infection to development of infectiousness
• Incubation period
  ❖ the time interval from infection to development of signs of disease
  ❖ not always a fixed period of time, shows some variation due to
    • route of infection
    • virulence of agent
    • host factors (age, immune status)
  ❖ follows a log normal distribution
Infection

• Infection is the entry and development or multiplication of an infectious agent in the body of man or animals. An infection does not always cause illness.

• There are several levels of infection (Gradients of infection):
  – Colonization (S. aureus in skin and normal nasopharynx)
  – Subclinical or inapparent infection (polio)
  – Latent infection (virus of herpes simplex)
  – Manifest or clinical infection
• **Infectious period**
  – the time during which the host can infect another susceptible host

• **Non-infectious period**
  – the time interval between infection to development of clinical disease
contamination

• The presence of an infectious agent on a body surface, on or in clothes, beddings, toys, surgical instruments or dressings, or other articles or substances including water and food
• Temporal patterns of onset can provide insight into the nature of the disease we’re dealing with (even when we don’t know the cause)
Terms used to describe the temporal pattern of disease in a population:

- endemic
- disease occurs at expected frequency
- epidemic
- disease occurs at greater than expected frequency
- pandemic
- huge epidemic (international)
- sporadic
- single case or a cluster of cases
Endemic

– disease occurs at expected frequency
– disease present in population or region at all times
– level of disease usually low and predictable
Epidemic

– disease occurs at greater than expected frequency
– incidence exceeds expected
– usually infectious disease or poisoning
– in animals, occasionally referred as epizootic disease
– may be point source or propagated
– examples:
  • influenza in humans
  • avian influenza
  • foot-and-mouth disease
Endemic vs Epidemic

Number of Cases of a Disease vs Time

Endemic

Epidemic
Pandemic and Exotic

• An epidemic usually affecting a large proportion of the population, occurring over a wide geographic area such as 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.
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.
Sporadic

– single case or cluster of cases
– infrequent disease occurrence
– irregular and unpredictable
– examples:
  • Legionnaire’s disease
  • food poisoning
Nature of epidemic depends on

– characteristics of agent (virulence) and host (susceptibility)
– contact rate
– population density
Type of epidemics
- Common source[1]
- Propagated (contagious)[2]
Common source epidemics

– subjects are exposed to a common noxious influence

– common point source epidemics
  • group is exposed over a relatively short period then disease cases will emerge over one incubation period
  • curve rises rapidly and contains a definite peak at the top, followed by a gradual decline

– common continuous source epidemics
  • group is exposed continuously and cases emerge over more than one incubation period
  • curve rises rapidly, no definite peak
Propagated epidemics

– occur when the agent is transmitted through the population from host to host (typically infectious conditions)

– propagated epidemics, in theory, show a series of progressively taller peaks one incubation period apart
Annual variation

– many infectious diseases exhibit marked and repetitive cyclical trends
– due to infection exhausting the susceptible population
– examples
  • measles, pertussis, polio
Seasonal variation

– vector-transmitted diseases (malaria, dengue fever, St Louis encephalitis) depend on exposure to infected mosquito vectors

– disease transmission only occurs during the warmer months of the year
Koch’s Postulates

- The same organism is present in every case
- It is isolated or grown in pure culture
- The disease can be reproduced in healthy animals after infection with pure culture
- The identical pathogen is reisolated from the experimental animals
Chain of Infection

Etiologic Agent → Transmission → Host

- Pathogenicity
- Infection dose
- Reservoir
- Source

- Contact
- Common vehicle
- Airborne
- Vector

- Individual host factors
- Nonspecific resistance
- Specific immunity
Epidemiologic Triad-Related Concepts

Infectivity (ability to infect)

\[
\text{Infectivity} = \left( \frac{\text{number infected}}{\text{number susceptible}} \right) \times 100
\]

Pathogenicity (ability to cause disease)

\[
\text{Pathogenicity} = \left( \frac{\text{number with clinical disease}}{\text{number infected}} \right) \times 100
\]

Virulence (ability to cause death)

\[
\text{Virulence} = \left( \frac{\text{number of deaths}}{\text{number with disease}} \right) \times 100
\]

All are dependent on host factors
Components of the infectious process

- Agent
- Reservoir
- Portals of entry and exit
- Transmission
- Immunity
Agent

- infectious = biologic organism living and replicating within a host
- infectious disease = infection + illness
- contamination = agent on exterior surface near host
Types of agents

- helminths (parasitic worms)
- fungi and yeasts (lower plants, lack chlorophyll)
- protozoa (eucaryotes; complex life cycles)
- bacteria (capable of independent reproduction)
- rickettsia (intracellular reproduction; require Ixodes tick carrier)
- viruses (submicroscopic; have genetic material but incapable of multiplication outside of host)
- prions (‘infectious proteins’)

(I): Source or Reservoir

• The starting point for the occurrence of a communicable disease is the existence of a reservoir or source of infection.
Source of infection

- Any living organism in which infectious agent lives, multiplies & from which the host acquires the agent.
Source of infection

- types of sources
  - symptomatic cases
  - Carriers
Reservoirs

- The whole species or other environment where the agent multiplies
- Without the reservoir, the agent can’t perpetuate
- Types of reservoirs
  - Symptomatic cases
  - Carriers
  - Animals
  - Inanimate objects
Types of reservoirs

- Human reservoir
- Animal reservoir
- Non-living reservoir
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”
Carriers

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

• It is “an infected person or animal that harbors a specific infectious agent in the absence of discernible (visible) clinical disease and serves as a potential source of infection to others.

• Three elements have to occur to form a carrier state:
  – The presence in the body of the disease agent.
  – The absence of recognizable symptoms and signs of disease.
  – The shedding of disease agent in the discharge or excretions.
Carrier = contagious person without discernable signs of disease

– types of carriers
  • inapparent throughout (e.g. polio)
  • incubatory (e.g. Hepatitis B, HIV)
  • convalescent (e.g. Salmonella typhi)

• The carrier state

  – asymptomatic carriers of infection play an important role in spreading disease
Infectivity

– the ability of an agent to cause infection in a susceptible host
– in theory, depends on the minimum number of infectious particles required to establish infection
– in diseases spread from person to person, the proportion of susceptible individuals who develop infection after exposure
– the secondary attack rate is a measure of infectivity
Pathogenicity

– the ability of the infectious agent to induce disease

– agents with high pathogenicity
  • viruses causing rabies, smallpox, measles, chicken pox

– agents with low pathogenicity
  • polio virus, arboviruses (mosquito borne)

Virulence

• describes the severity of disease, after infection has occurred
• measured using the case fatality rate
Transmission
direct (host → host)
indirect (host → exudate or secretion → host)

(II): Modes of transmission

**Mode of transmission**

- **Direct transmission**
  - Direct contact
  - Droplet infection
  - Contact with soil
  - Inoculation into skin or mucosa
  - Trans-placental (vertical)

- **Indirect transmission**
  - Vehicle-borne
  - Vector-borne:
    - Mechanical
    - Biological
  - Air-borne
  - Fomite-borne
  - Unclean hands and fingers
HOST

Immunity

– all factors that alter likelihood and severity of infection after host is exposed

– types of immunity
  • innate = inborn
  • acquired = ‘learned’ response needed
Importance of Studying Communicable Diseases Epidemiology

• Changes of the pattern of infectious diseases
• Discovery of new infections
• The possibility that some chronic diseases have an infective origin.