Introduction to Public Health

Chain of Infection

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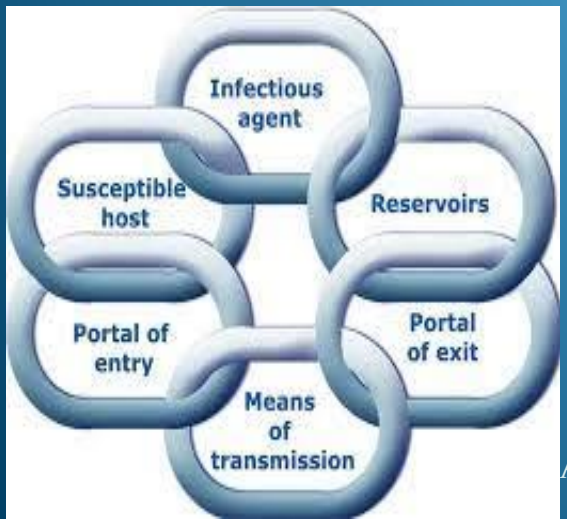


Public Health
Prevent. Promote. Protect.

Chain of Infection

The traditional model (epidemiological triad) illustrates that infectious diseases result from the interaction of agent, host, and environment.

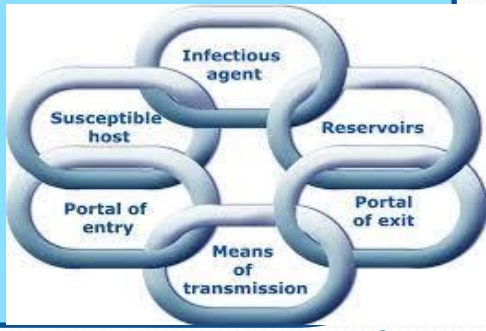
More specifically , transmission occurs when:

1. the agent leaves its reservoir or host through a portal of exit, and

2. is conveyed by some mode of transmission, and

3. enters through an appropriate portal of entry to infect a susceptible host.

This is sometimes called the chain of infection



Reservoir

- The reservoir of an agent is the habitat in which an infectious 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.*

Human reservoirs

Many of the common infectious diseases have human reservoirs

Diseases which are transmitted from person to person without intermediaries

i. e. sexually transmitted diseases, measles, mumps, streptococcal infection, most respiratory pathogens, and many others.

Smallpox was eradicated after the last human case was identified and isolated because humans were the only reservoir for the smallpox virus.

Two types of human reservoir exist:

- persons with symptomatic illness
- carriers

A carrier is a person without apparent disease who is nonetheless capable of transmitting the agent to others. Carriers may be :

Asymptomatic carriers, who never show symptoms during the time they are infected, such as EBV and Cytomegalovirus, Herpes simplex, typhoid fever, measles , HIV

Incubatory carriers :A person infected with a certain microorganism but in such an early stage of disease that clinical manifestations are not apparent , typhoid fever, hepatitis A, mumps, chicken pox.

Convalescent carriers, a person who is clinically recovered from an infectious disease but still capable of transmitting the infectious agent to others.

This happens with many diseases. **Example**: Salmonella patients may excrete the bacteria in feces for several weeks, and rarely even for a year or more.

This is most common in infants and young children. Treatment with inappropriate antibiotics may prolong the convalescent carrier phase.

A chronic carrier is one who continues to harbor an agent (such as hepatitis B virus or *Salmonella typhi*— *the agent of typhoid fever) for an* extended time (months or years) following the initial infection.

Carriers commonly transmit disease because they do not recognize they are infected and consequently take no special precautions to prevent transmission.

Symptomatic persons, on the other hand, are usually less likely to transmit infection widely because their symptoms increase their likelihood of being diagnosed and treated, thereby reducing their opportunity for contact with others.

Animal reservoirs

Infectious diseases that are transmissible under normal conditions from vertebrate animals to humans are called zoonosis.

Such diseases include brucellosis (cows ,sheep and pigs),

Anthrax (sheep, horses) | plague (rodents) | leishmania (dogs)

Rabies (bats, raccoons, dogs, and other mammals)

- Another group of diseases with animal reservoirs are those caused by viruses transmitted by insects.
- Or caused by parasites that have complex life cycles, with different reservoirs at different stages of development.

Such as malaria (requiring mosquitoes) and schistosomiasis (requiring fresh water snails).

Lyme disease is a zoonotic disease of deer incidentally transmitted to humans by the deer tick.

Environmental reservoirs

- Plants, soil, and water in the environment are also reservoirs for some infectious agents.
- Many fungal agents, such as those causing histoplasmosis, live and multiply in the soil.
- The primary reservoir of Legionnaires' bacillus appears to be pools of water, including those produced by cooling towers.
- Parasitic infection, Hookworm (ancylostoma duodenale), toxoplasmosis

Portal of exit

- Portal of exit is the path by which an agent leaves the source host, usually corresponds to the site at which the agent is localized.

- Thus, tubercle bacilli and influenza viruses exit the **respiratory tract**, cholera vibrio in **feces**, *Sarcoptes scabiei in scabies* ***skin*** *lesions*.
- **Genitourinary:** This portal of exit is the route of sexually transmitted diseases, including syphilis, gonorrhea, chlamydia, and HIV, schistosomes through urine.

- Some blood borne agents can exit by crossing the **placenta** (rubella, syphilis, toxoplasmosis), while others exit by way of the skin (percutaneously) through cuts or needles (hepatitis B) or blood-sucking arthropods (malaria).

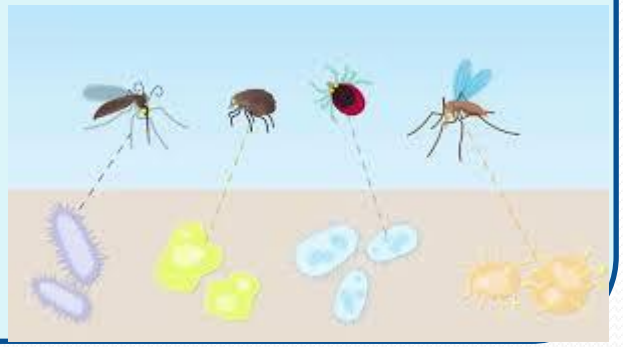
- Portal of exit is important for the prevention of the infection.

Modes of transmission

After an agent exits its natural reservoir, it may be transmitted to a susceptible host in numerous ways. These modes of transmission are classified as:

- **Direct**
  - Direct contact
  - Droplet spread

- **Indirect**
  - Airborne
  - Vehicle borne
  - Vector borne
    - Mechanical
    - Biologic



Direct transmission

- there is essentially immediate transfer of the agent from a reservoir to a susceptible host by direct contact or droplet spread.

- Direct contact occurs through mucous membranes, skin-to-skin contact, and sexual relations.
- Direct contact refers also to contact with soil or vegetation harboring infectious organisms.
- Thus, infectious mononucleosis ("kissing disease") and gonorrhea are spread from person-to-person by direct contact.

- Hookworm is spread by direct contact with contaminated soil.

- Droplet spread refers 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.

Indirect transmission

- An agent is carried from a reservoir to a susceptible host by suspended air particles or by animate (vector) or inanimate (vehicle) intermediaries.
- Most vectors are arthropods such as mosquitoes, fleas, and ticks. These may carry the agent through purely **mechanical means.** For example, flies carry *Shigella on leges; fleas carry Yersinia pestis (agent that causes plague) in the gut and deposit the agent on the skin of a new host.*
- *In* mechanical transmission, the agent does not multiply or undergo physiologic changes in the vector.

- This is in contrast to instances in which an agent undergoes part of its life cycle inside a vector before being transmitted to a new host.

- When the agent undergoes changes within the vector, the vector is serving as both an intermediate host and a mode of transmission. This type of indirect transmission is a biologic transmission.

- **Vehicles** that may indirectly transmit an agent include food, water, biologic products (blood), and fomites (inanimate objects such as handkerchiefs, bedding, or surgical scalpels).

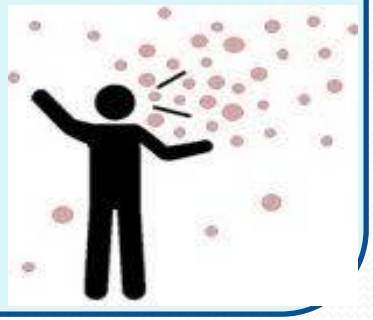
- As with vectors, vehicles may passively carry an agent—as food or water may carry hepatitis A virus—or may provide an environment in which the agent grows, multiplies, or produces toxin—as improperly canned foods may provide an environment in which *Clostridium botulinum produces toxin.*

Air-born transmission

- By particles that are suspended in air.
- There are two types of these particles: dust and droplet nuclei.

- **Airborne dust** includes infectious particles blown from the soil by the wind as well as material that has settled on surfaces and become resuspended by air currents.

- **Droplet nuclei** are the residue of dried droplets. The nuclei are less than 5 μ (microns) in size and may remain suspended in the air for long periods, may be blown over great distances, and are easily inhaled into the lungs and exhaled.
- Tuberculosis, for example, is believed to be transmitted more often indirectly, through droplet nuclei, than directly, through droplet spread.



- Legionnaires' disease and histoplasmosis are also spread through airborne transmission.

Portal of entry

- An agent enters a susceptible host through a portal of entry.
- The portal of entry must provide access to tissues in which the agent can multiply, or a toxin can act. Often, organisms use the same portal to enter a new host that they use to exit the source host.
- For example, influenza virus must exit the respiratory tract of the source host and enter the respiratory tract of the new host.
- The route of transmission of many enteric (intestinal) pathogenic agents is described as "fecal-oral" because the organisms are shed in feces, carried on inadequately washed hands, and then transferred through a vehicle (such as food, water, or cooking utensil) to the mouth of a new host.
- Other portals of entry include the skin (hookworm), mucous membranes (syphilis, trachoma), and blood (hepatitis B).

Host

The final link in the chain of infection is a susceptible host.

Susceptibility of a host depends on:

1. **genetic factors**, An individual's genetic makeup may either increase or decrease susceptibility.
2. specified acquired immunity, vaccination, active or passive.
3. other general factors which alter an individual's ability to resist infection or to limit pathogenicity.

General factors which defend against infection include the skin, mucous membranes, gastric acidity, cilia in the respiratory tract, the cough reflex, and nonspecific immune response.

General factors that may increase susceptibility are malnutrition, alcoholism, and disease or therapy which impairs the nonspecific immune response.

Specific acquired immunity refers to protective antibodies that are directed against a specific agent. Individuals gain protective antibodies in two ways:

1) They develop antibodies in response to infection, vaccine, or toxoid; immunity developed in these ways is called **active immunity**.

2) They acquire their mothers' antibodies before birth through the placenta or they receive injections of antitoxins or immune globulin; immunity that is acquired in these ways is called **passive immunity**.

- Note that the chain of infection may be interrupted when an agent does not find a susceptible host. This may occur if a high proportion of individuals in a population is resistant to an agent.
- These persons limit spread to the relatively few who are susceptible by reducing the probability of contact between infected and susceptible persons. This concept is called **herd immunity.**
- The degree of herd immunity necessary to prevent or abort an outbreak varies by disease.

- In theory, herd immunity means that not everyone in a community needs to be resistant (immune) to prevent disease spread and occurrence of an outbreak.

- In practice, herd immunity has not prevented outbreaks of measles and rubella in populations with immunity levels as high as 85 to 90%.

- One problem is that, in highly immunized populations, the relatively few susceptible persons are often clustered in population subgroups, usually defined by socioeconomic or cultural factors. If the agent is introduced into one of these subgroups, an outbreak may occur.

Implications for public health

By knowing how an agent exits and enters a host, and what its modes of transmission are, we can determine appropriate control measures.

In general, we should direct control measures against the link in the infection chain that is most susceptible to interference. For some diseases, the most appropriate intervention may be directed at controlling or eliminating the agent at its source.

In the hospital setting, patients may be treated and/or isolated, with appropriate:

1. "enteric precautions,"
2. "respiratory precautions,"
3. "universal precautions," and the like for different exit pathways.

In the community, soil may be decontaminated or covered to prevent escape of the agent.

- Sometimes, we direct interventions at the mode of transmission.

- For direct transmission, we may provide treatment to the source host or educate the source host to avoid the specific type of contact associated with transmission.

- In the hospital setting, since most infections are transmitted by direct contact, hand washing is the single most important way to prevent diseases from spreading.
- For vehicle borne transmission, we may decontaminate or eliminate the vehicle.

- For fecal-oral transmission, we may also try to reduce the risk of contamination in the future by rearranging the environment and educating the persons involved in better personal hygiene.

- For airborne transmission, we may modify ventilation or air pressure, and filter or treat the air.
- For vector borne transmission, we usually attempt to control (i.e., reduce or eradicate) the vector population.
- Finally, we may apply measures that protect portals of entry of a susceptible potential host or reduce the susceptibility of the potential host. For example, a dentist's mask and gloves are intended to protect the dentist from a patient's blood, secretions, and droplets, as well to protect the patient from the dentist.
- Prophylactic antibiotics and vaccination are strategies to improve a potential host's defenses.

Epidemic Disease Occurrence

Level of disease

■The amount of a particular disease that is usually present in a community is the baseline level of the disease.

■This level is not necessarily the preferred level, which should in fact be zero; rather it is the observed level.

■Theoretically, if no intervention occurred and if the level is low enough not to deplete the pool of susceptible persons, the disease occurrence should continue at the baseline level indefinitely.

■Thus, the baseline level is often considered the **expected level of** the disease.

■ For example, over the past 4 years the number of reported cases of poliomyelitis has ranged from 5 to 9. Therefore, assuming there is no change in population, we would expect to see approximately 7 reported cases next year.

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

1) a persistent level of occurrence with a low to moderate disease level is referred to as an **endemic level**;
2) a persistently high level of occurrence is called **a hyperendemic level**;
3) An irregular pattern of occurrence, with occasional cases occurring at irregular intervals is called **sporadic.**

Occasionally, the level of disease rises above the expected level. When the occurrence of a disease within an area is clearly in excess of the expected level for a given time period, it is called an **epidemic**.
Public health officials often use the term outbreak, which means the same thing.
When an epidemic spreads over several countries or continents, affecting a large number of people, it is called a **pandemic**.

More specifically, an epidemic may result from the following:

- a recent increase in amount or virulence of the agent.
- the recent introduction of the agent into a setting where it has not been before.
- an enhanced mode of transmission so that more susceptible are exposed.
- some change in the susceptibility of the host response to the agent.
- factors that increase host exposure or involve introduction through new portals of entry.

Epidemic patterns

We sometimes classify epidemics by how they spread through a population, as shown below:

- Common source
  - Point
  - Continuous
- Propagated
  - Mixed
  - Other

Common source outbreak

When group of persons is exposed to a common noxious influence, such as an infectious agent or a toxin.
If the group is exposed over a relatively brief period, so that everyone who becomes ill develops disease at the end of one incubation period, then the common source outbreak is further classified as a **point source outbreak.**

i.e.

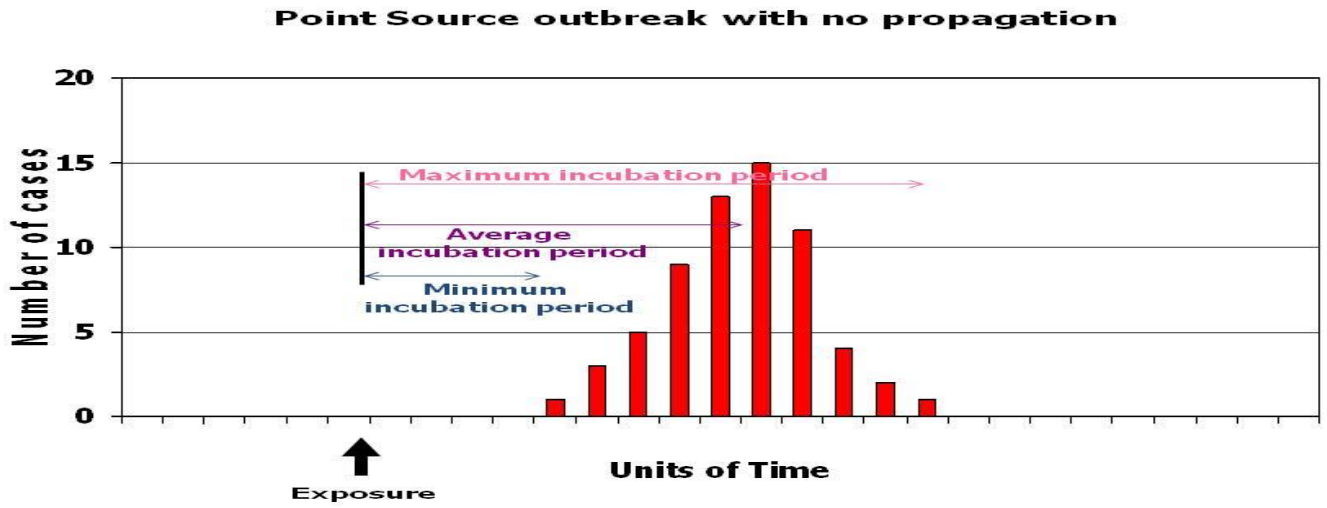
- epidemic of leukemia cases in Hiroshima following the atomic bomb blast.
- the epidemic of hepatitis A among college football players who unknowingly drank contaminated water after practice one day each had a point source of exposure.

When the number of cases in a point source epidemic is plotted over time, the resulting epidemic curve classically has a steep upslope and a more gradual downslope (a so-called "normal distribution").

Point Source outbreak

Here, all cases appear to occur within one incubation period, suggesting that cases did not arise from person-to-person spread.

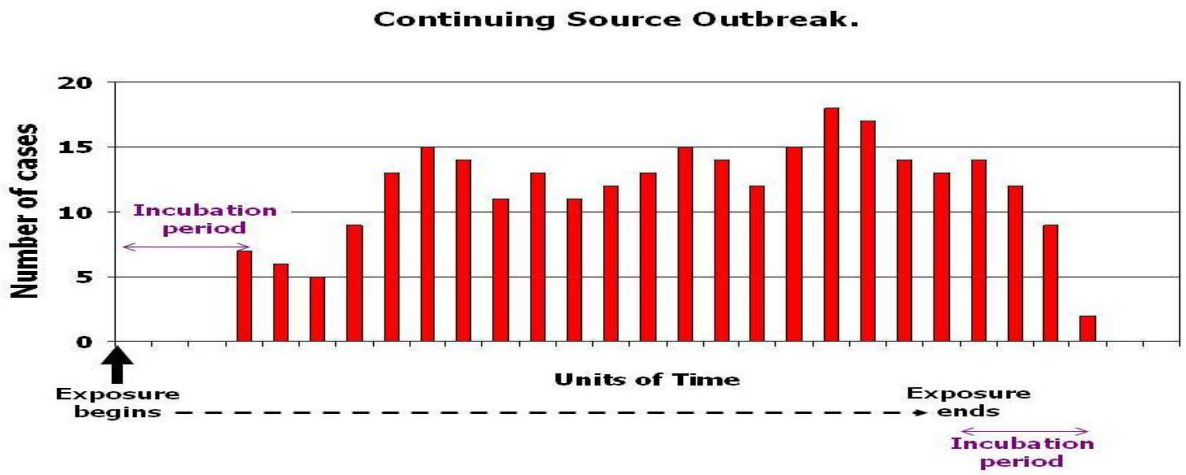
The fact that the outbreak was of short duration suggests that it was a single, brief (hence "point") exposure that did not persist over time.
Examples include that embarrassing diarrhea saga following the neighbor's summer barbecue, or a respiratory illness in workers following a breakdown of a fume hood.



Continuing Source outbreak

- As with the point source outbreak, a group of people are exposed to a single noxious influence.
- **But here the exposure continues over a longer time (e.g., a contaminated water supply that doesn't get fixed), so the outbreak persists for longer.
- The relatively abrupt beginning of the outbreak suggests that many people were exposed simultaneously, rather than it spreading via transmission from one case to another.

- The fact that no cases arise beyond one incubation period following the termination of the exposure also supports this conclusion.



Person-to-Person Spread

- Here the disease spreads via person-to-person contact – the classic infectious disease pattern.
- Controlling the source is no longer sufficient to control the outbreak.
- **Index case with limited spread.**

- Here a single '**index**' **case** (for example, a returning traveler) infects other people, and cases arise after an incubation period. (Perhaps confusingly, you may also hear this called a point source with secondary transmission).

- The outbreak wanes when the infected people no longer transmit the infection to other susceptible people, perhaps because of successful control measures (isolation or quarantine).

propagated outbreak

- An outbreak that does not have a common source, but instead spreads gradually from person to person—usually growing as it spreads—is called a **propagated outbreak.**

- **Usually** transmission is by direct person-to-person contact, as with syphilis.
- Transmission may also be vehicle borne, as the transmission of hepatitis B or HIV by sharing needles, or vector borne, as the transmission of yellow fever by mosquitoes.

- In a propagated epidemic, cases occur over more than one incubation period.

- In theory, the epidemic curve of a propagated epidemic would have a successive series of peaks reflecting increasing numbers of cases in each generation.

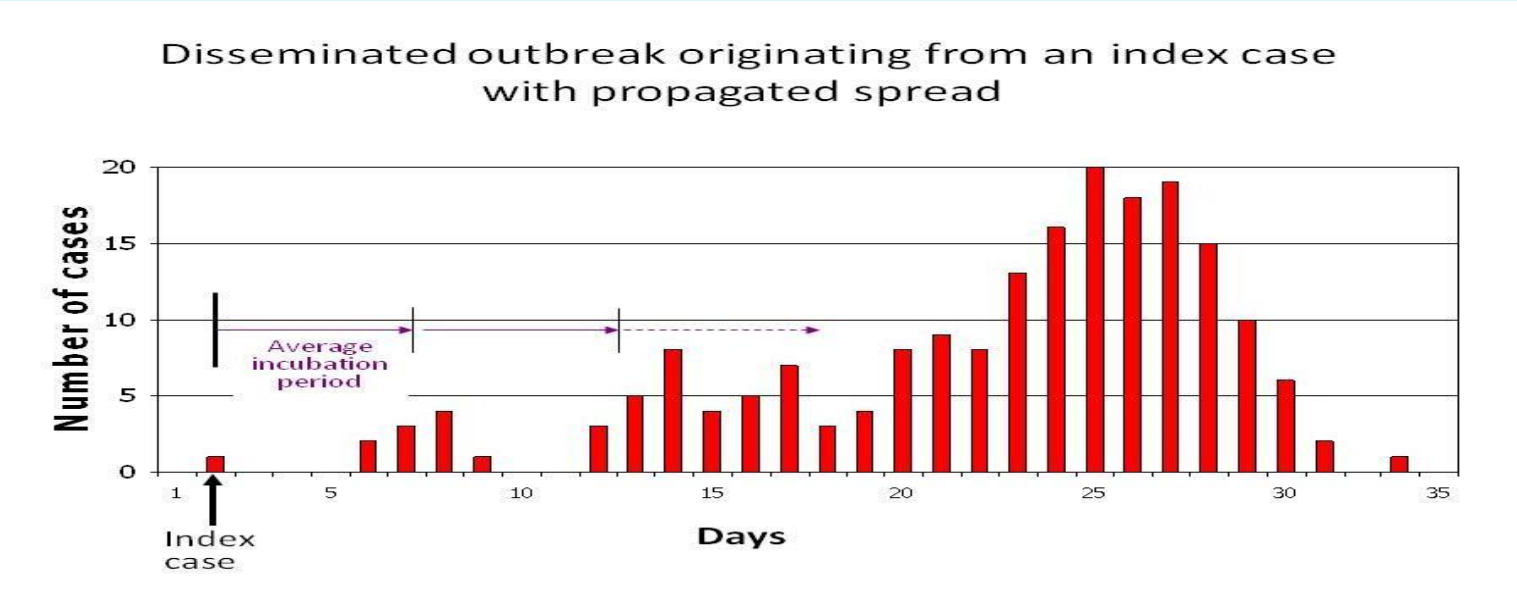
Propagated Spread .....cont....

This begins like an infection from an index case but then develops into a full-blown epidemic with secondary cases infecting new people who, in turn, serve as sources for yet other cases.

This produces successively taller peaks, initially separated by one incubation period, but the peaks tend to merge into waves with increasing numbers of cases in each generation.

The epidemic continues until the :

1. remaining numbers of susceptible individuals declines or
2. until intervention measures take effect.



Investigation of an epidemic

There is a systematic method to investigate an epidemic as in case of an epidemic of typhoid fever or meningitis or hepatitis or any other disease:

1. Verification of the diagnosis. It is important to make sure that the cases under investigation are definite cases of that disease. This is done by careful history, physical examination and relevant laboratory investigation. For example, blood culture in typhoid fever is very reliable diagnostic method.
2. Confirmation of the existence of epidemic (excess cases above normal expectancy). This is ascertained by comparing the reported cases at the time of the epidemic with cases reported in previous months or years.
3. Identification of the affected cases and their characteristics. This is important because, it may help to identify a common experience or exposure of the cases and thus to facilitate the identification of source of epidemic.

4. Further investigation of the population at risk, contacts, carriers and hidden cases.

5. Study of the environment to identify factors which are likely to be related to the epidemic. Search for any change in the environment at or immediately before the onset of the epidemic.

6. Formulation of hypotheses about the epidemic regarding source of infection, mode of transmission and existence of reservoir of infection and carriers. Management of the epidemic. This includes:

a. Treatment of cases and carriers.

b. Protection of high risk and susceptible persons ; immunization and chemoprophylaxis

c. Writing a report about the epidemic.

d. Continuous surveillance to prevent future epidemics.

e. Experimental verification of agent of the disease and mode of transmission.


Thank You!